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Mr. Jeff DeRouen
Executive Director
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, Kentucky 40601

August 4, 2011

RE: ***The 2011 Joint Integrated Resource Plan of Louisville Gas and Electric Company and Kentucky Utilities Company*** **– Case No. 2011-00140**

Dear Mr. DeRouen:

Please find enclosed and accept for filing the original and ten (10) copies of the response of Louisville Gas and Electric Company and Kentucky Utilities Company to the Initial Interrogatories of Rick Clewett, Drew Foley, Janet Overman, Gregg Wagner, the Natural Resource Defense Council, and the Sierra Club dated July 15, 2011, in the above-referenced matter.

Also enclosed are an original and ten (10) copies of a Petition for Confidential Protection regarding certain information contained in response to Question No. 7.

Should you have any questions regarding the enclosed, please contact me at your convenience.

Sincerely,

Rick E. Lovekamp

Rick E. Lovekamp

cc: Parties of Record

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

THE 2011 JOINT INTEGRATED RESOURCE PLAN	**)**	
OF LOUISVILLE GAS AND ELECTRIC COMPANY	**)**	**CASE NO.**
AND KENTUCKY UTILITIES COMPANY	**)**	**2011-00140**

RESPONSE OF
LOUISVILLE GAS AND ELECTRIC COMPANY
AND
KENTUCKY UTILITIES COMPANY
TO THE INITIAL INTERROGATORIES OF
RICK CLEWETT, DREW FOLEY, JANET OVERMAN, GREGG WAGNER,
THE NATURAL RESOURCE DEFENSE COUNCIL, AND THE SIERRA CLUB
DATED JULY 15, 2011

FILED: August 4, 2011

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Charles R. Schram**, being duly sworn, deposes and says that he is Director – Energy Planning, Analysis and Forecasting for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Charles R. Schram

Charles R. Schram

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 3rd day of August 2011.

Tammy J. Elzy (SEAL)
Notary Public

My Commission Expires:

November 9, 2014

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Michael E. Hornung**, being duly sworn, deposes and says that he is Manager of Energy Efficiency Planning & Development for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Michael E. Hornung

Michael E. Hornung

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 3rd day of August 2011.

Tammy J. Ely (SEAL)
Notary Public

My Commission Expires:

November 9, 2014

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Edwin R. Staton**, being duly sworn, deposes and says that he is Vice President, Transmission for Louisville Gas and Electric Company and Kentucky Utilities Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Edwin R. Staton

Edwin R. Staton

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 3rd day of August 2011.

Tammy J. Ely (SEAL)
Notary Public

My Commission Expires:

November 9, 2014

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to the Initial Interrogatories of
Rick Clewett, Drew Foley, Janet Overman, Gregg Wagner, the Natural Resource Defense Council, and the Sierra Club

Case No. 2011-00140

Question No. 1

Witness: Charles R. Schram

Q-1. Refer to page 5-11 of the Resource Plan. Identify what efficiencies of the Energy Independence and Security Act "have been embedded into the models to construct the small commercial and residential forecasts," and explain how such efficiencies have been embedded.

A-1. Please refer to Volume 2, pp. 213-227 for a description of the Itron Statistically Adjusted End-Use models that calculated the commercial and residential usage per customer energy. The models include the impacts for the EISA and ARRA.

More specifically, the updated end-use efficiency projections incorporate the standards established by the Energy Independence and Security Act of 2007 (EISA). In 2007, new standards were established for a number of appliances including dishwashers, clothes washers, and dehumidifiers. By far, the new lighting standards will have the most significant impact on residential electricity usage. The new standards go into effect in 2012 and are expected to reduce overall residential average use by 1.5% to 2.5% (depending on the region) in the 2012-2014 timeframe. See attached documented titled "2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets" for more detail.

For the commercial forecasts, the expected impacts from both the 2007 Energy Independence and Security Act (EISA) and the 2009 American Recovery and Reinvestment Act (ARRA) primarily affect the end-use energy intensity projections but also affect the end-use efficiency and saturation projections. Commercial energy intensity is measured in terms of energy use per square foot. The end-use energy intensities incorporate end-use efficiency trends, increase in end-use saturation, and change in long-term term usage driven by price, and economic conditions. See attached document titled "2009 Commercial Electric Statistically Adjusted End-use (SAE) Spreadsheets" for more detail.

The impacts of EISA were first introduced in the commercial models in 2008, which was before the Companies adopted a commercial end-use model. More specifically, EISA introduced new and updated efficiency requirements for space heating and cooling, refrigeration and lighting. In addition, EISA mandated the use of energy efficient lighting in all Federal buildings.

Attachment to Question No. 1
2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets
Witness: Schram

2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets

The 2009 Residential SAE spreadsheets and models are based on the Energy Information Administration's (EIA) 2009 Annual Energy Outlook (AEO), which was released in April 2009. The 2009 residential SAE spreadsheets and *MetrixND* project files include the following:

- Updated equipment efficiency trends with information specific to Census Divisions
- Updated equipment and appliance saturation trends
- Updated structural indices
- Updated annual heating, cooling, water heating and Non-HVAC indices
- Updated regional sales forecasts

Equipment Efficiency Trends

The updated end-use efficiency projections incorporate the standards established by the Energy Independence and Security Act of 2007 (EISA). In 2007, new standards were established for a number of appliances including dishwashers, clothes washers, and dehumidifiers. By far, the new lighting standards will have the most significant impact on residential electricity usage. The new standards go into effect in 2012 and are expected to reduce overall residential average use by 1.5% to 2.5% (depending on the region) in the 2012-2014 timeframe. Though significant, the impact is not as severe as that reflected in the 2008 efficiency projections, as EIA assumes a greater penetration of Compact Fluorescent Lamps (CFL) prior to 2012 due to utility Demand Side Management (DSM) programs and market-driven CFL adoption.

Overall, there is little change in the national end-use efficiency projections between the 2009 and 2008 forecasts. The exceptions include water heating, lighting, and the miscellaneous end-use category. Water heater efficiencies are expected to increase at a somewhat faster rate than last year's forecast. Figure 1 shows the current and prior year water heating efficiency projections (as measured by the Energy Factor – EF) for the U.S.

Figure 1: Electric Water Heater Efficiency Projections (EF)

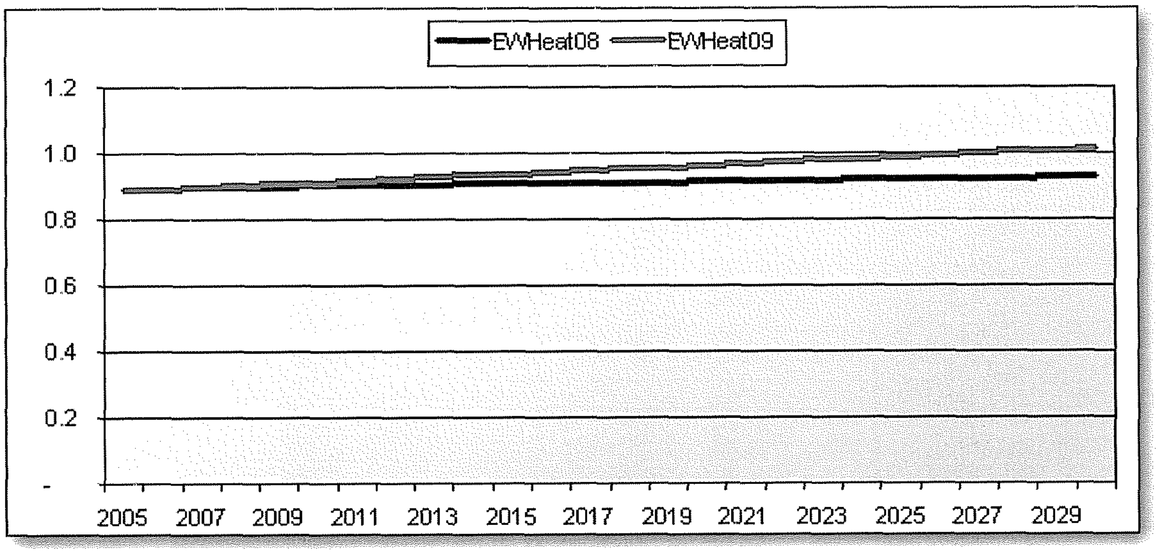
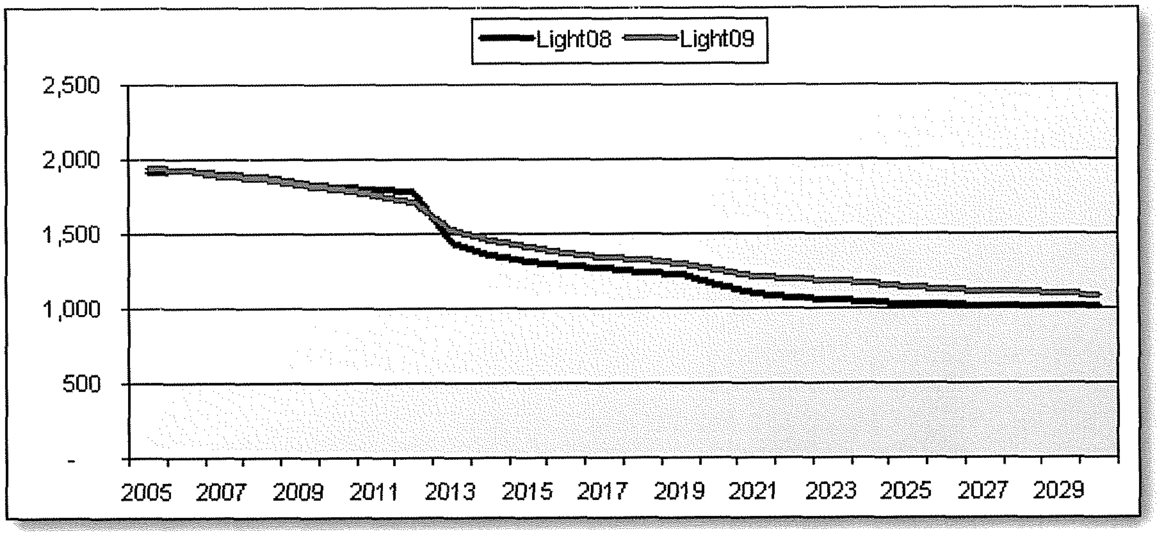


Figure 2 compares the 2009 and 2008 national lighting Unit Energy Consumption (UEC) forecasts.

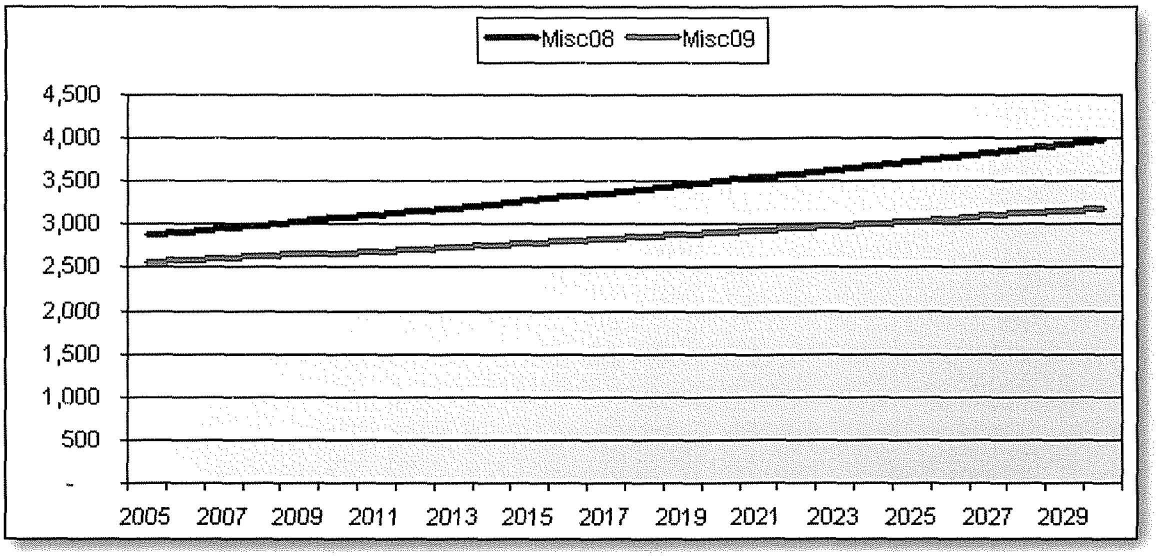
Figure 2: Average Lighting Usage Projections (kWh/year)



The 2009 lighting use forecast is projected to follow a less severe path than in the 2008 forecast. In the new forecast, EIA assumes a greater adoption of CFLs prior to the implementation of the 2012 lighting standards. As a result, the drop in lighting use in 2013 is not as severe. The new forecast also shows slightly higher lighting usage after 2013 when compared with the 2008 forecast.

Figure 3 compares the 2009 and 2008 miscellaneous UEC forecasts.

Figure 3: Average Household Miscellaneous Usage Projections (kWh)



The 2009 miscellaneous UEC is lower in the 2005 base year and increases at a slower rate through the forecast period. Part of the differences reflects changes in the miscellaneous category definition and re-allocation of base year end-use consumption across end-uses. A number of the starting 2005 end-use UECs were adjusted to reflect the results of UEC estimates calculated from the 2005 Residential Energy Consumption Survey (RECS). Last year, the 2005 UECs were based on the National Energy Modeling System (NEMS). Also, the EIA allocated more of the sales growth to specific end-uses with stronger end-use saturation projections.

Regional End-Use Efficiency Trends

The 2009 SAE spreadsheets incorporate efficiency information specific to each Census Division. Previously, national efficiency projections were used for heating and cooling equipment, as well as other equipment types such as water heaters, dryers, and dish washers. This year, efficiency projections are constructed from regional projections of equipment replacement, new purchases, and differences in base-year end-use stock efficiency. On a national basis, there are minor differences in projected efficiency trends from last year for most end-uses. However, there are some regional differences in air conditioning and water heating efficiency projections. Figure 4, Figure 5, and Figure 6 depict regional efficiency trends (as measured by the Seasonal Energy Efficiency Ratio – SEER and Energy Factor – EF) for New England, West South Central, Pacific, and South Atlantic Census Divisions and for the U.S. for cooling and water heating.

Figure 4: Central Air Conditioning Regional Efficiency Projections (SEER)

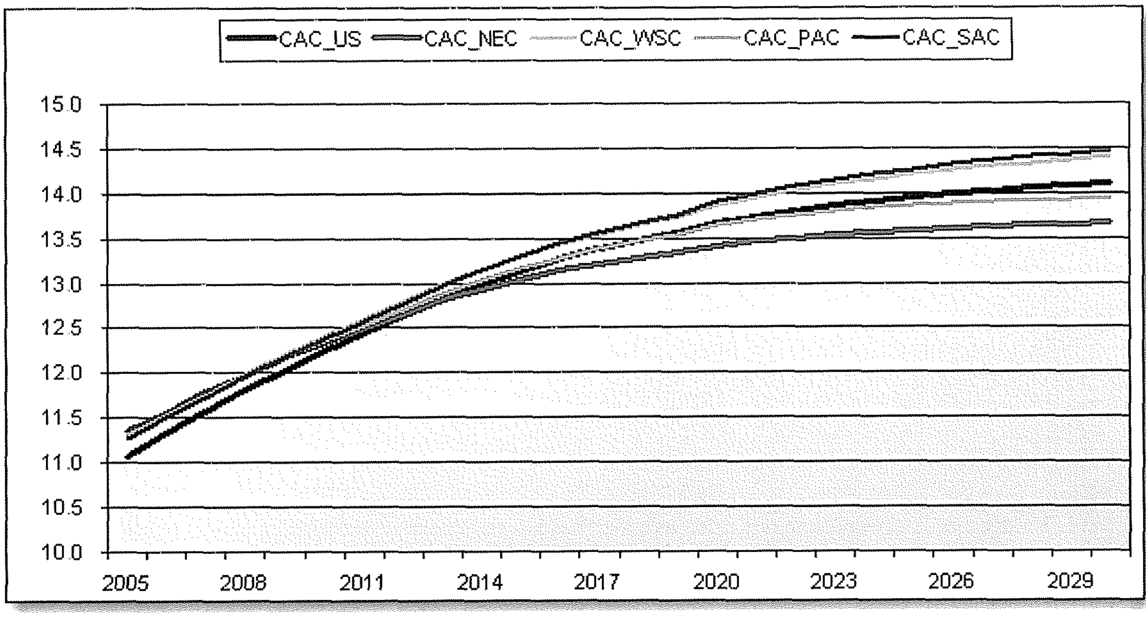


Figure 5: Room Air Conditioning Efficiency Projections (SEER)

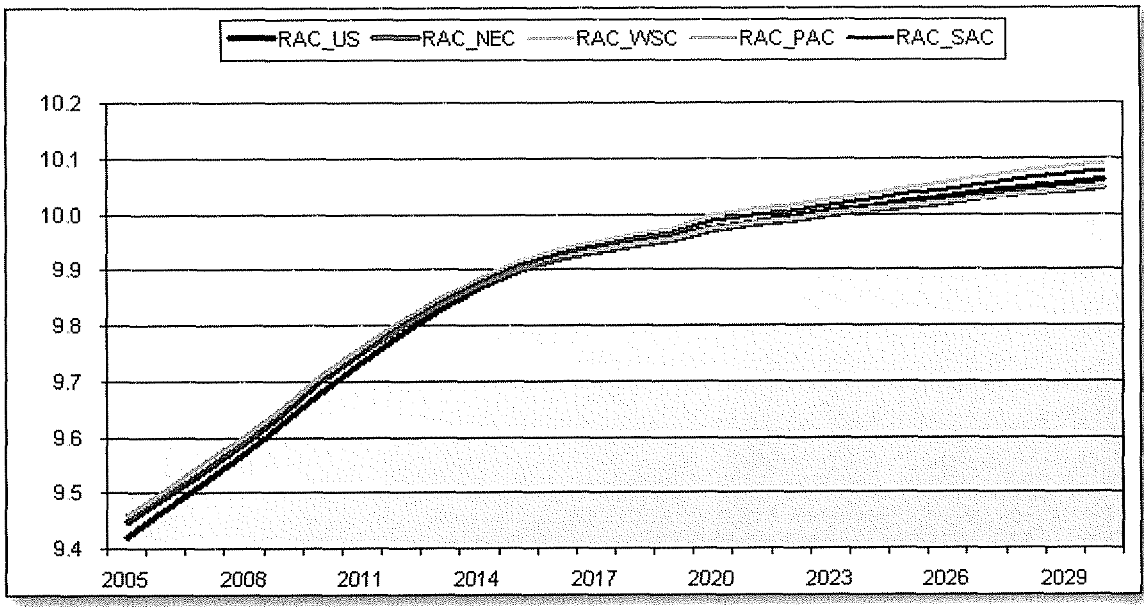
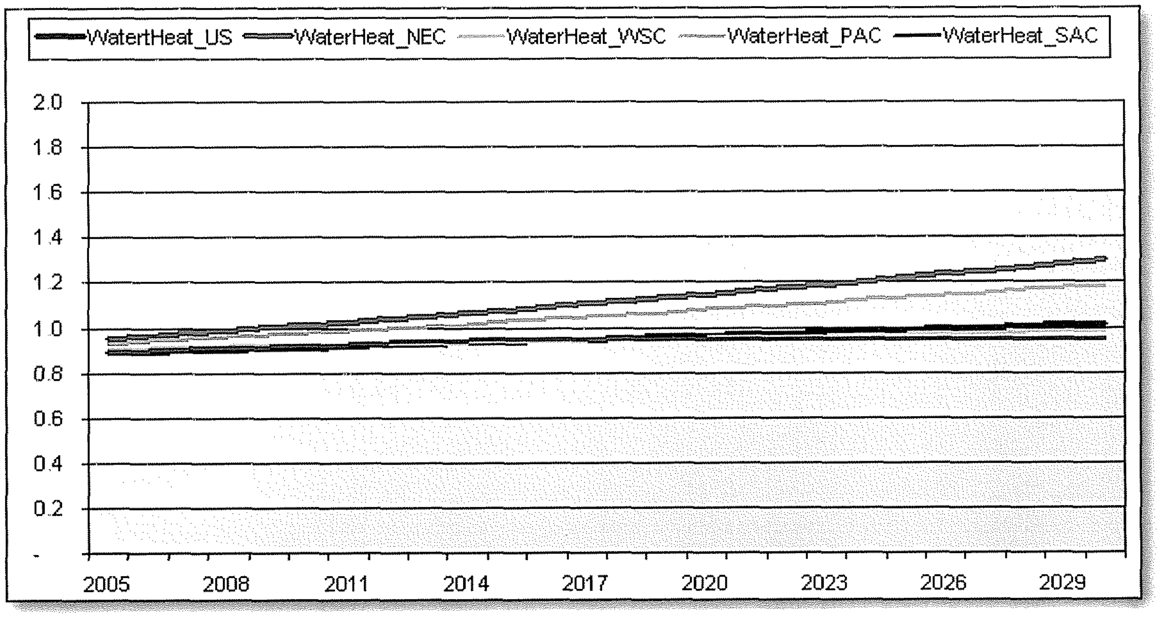


Figure 6: Electric Water Heater Efficiency Projections (EF)



Equipment Saturation Trends

Like last year, the 2009 saturation projections are based on the 2005 RECS. As a result, starting saturation levels (except for secondary heat) are largely unchanged from last year. Heat pump, central air conditioning, and room air conditioning saturation trends are unchanged. Electric water heating and secondary heat show the largest change as shown in Figure 7 and Figure 8.

Figure 7: Electric Water Heat Saturation Projections (U.S.)

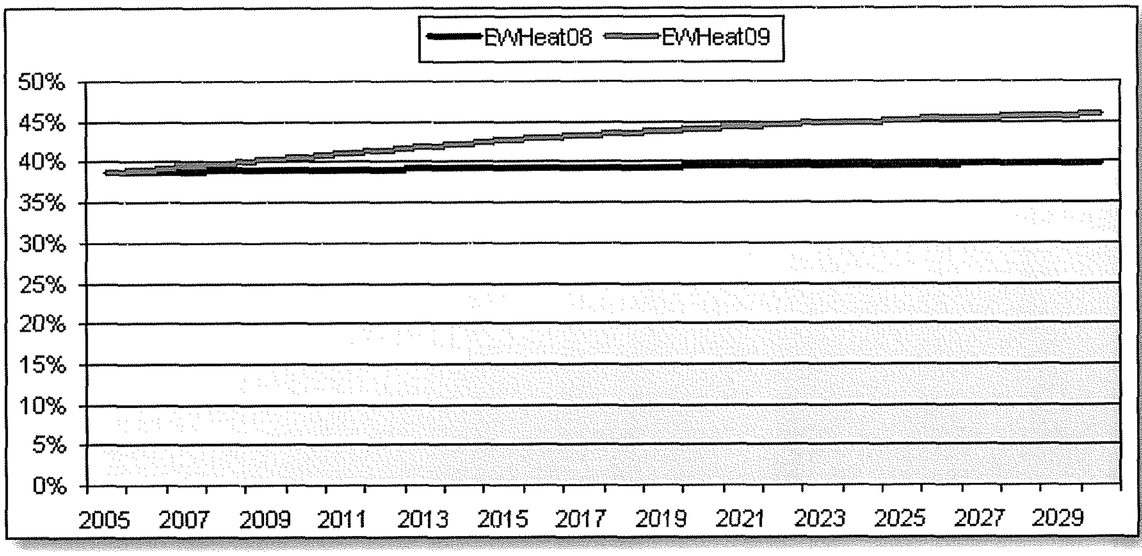
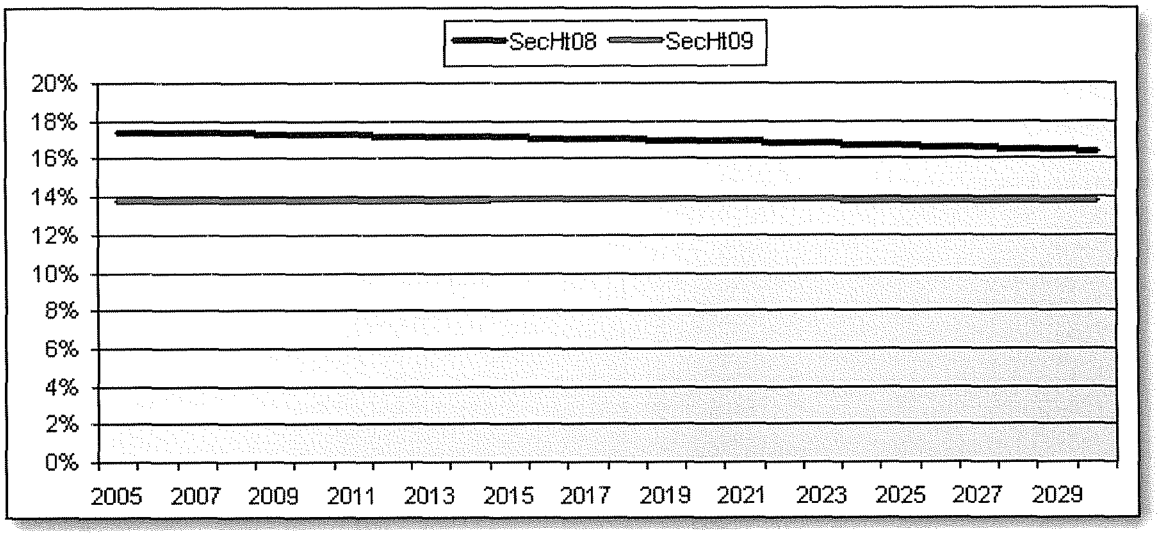


Figure 8: Secondary Heat Saturation (U.S.)



End-use saturation for the other end-uses increases at a somewhat faster rate than last year's forecast. Figure 9 through Figure 12 show saturation projections for select equipment/appliances across all Census Divisions.

Figure 9: Dishwasher Saturation Projections (U.S.)

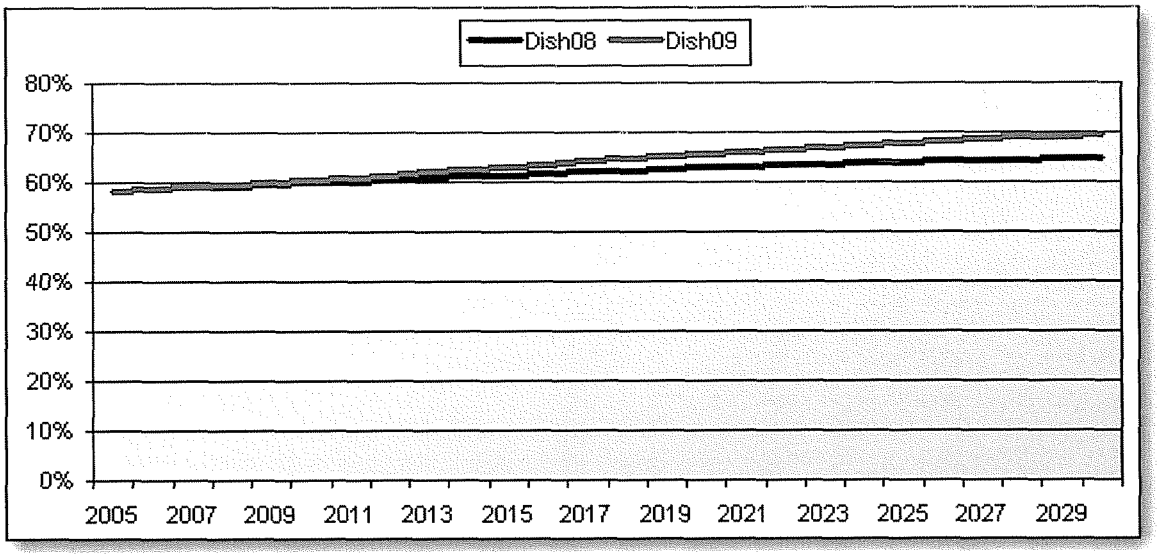


Figure 10: Clothes Washer Saturation Projections (U.S.)

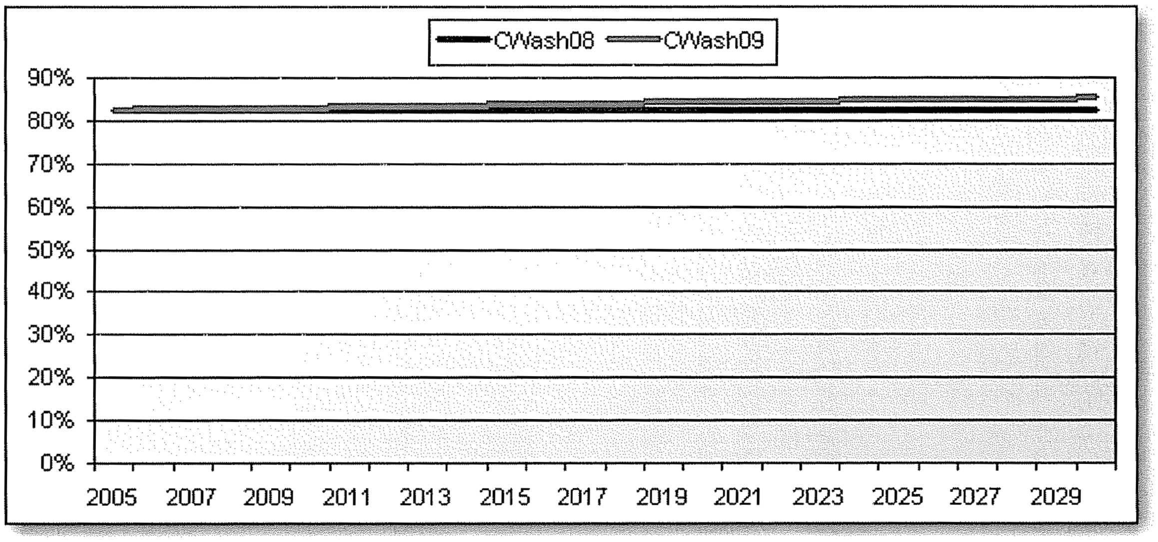


Figure 11: Electric Dryer Saturation Projections (U.S.)

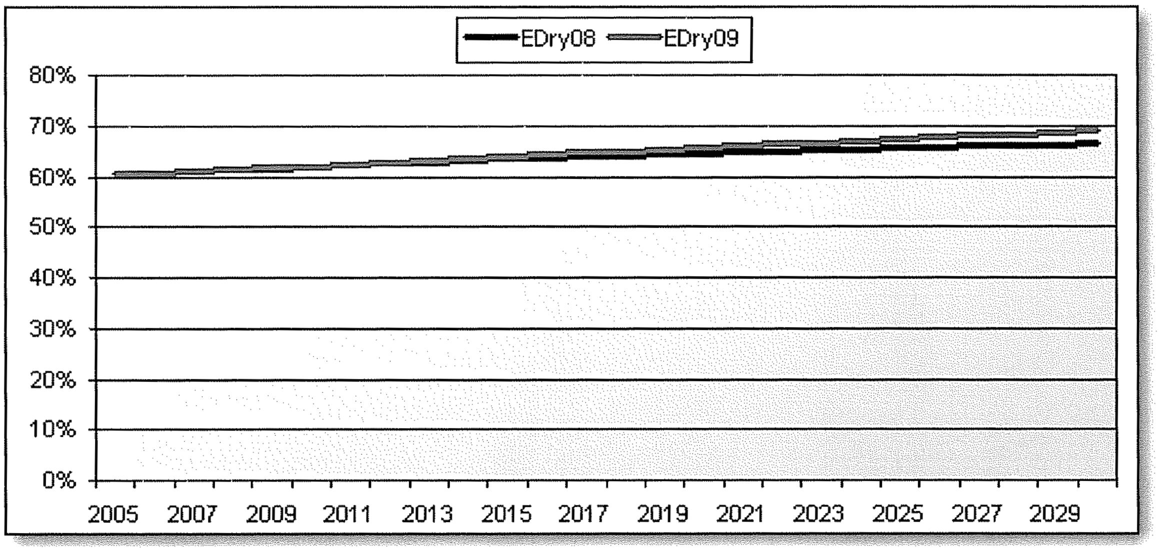
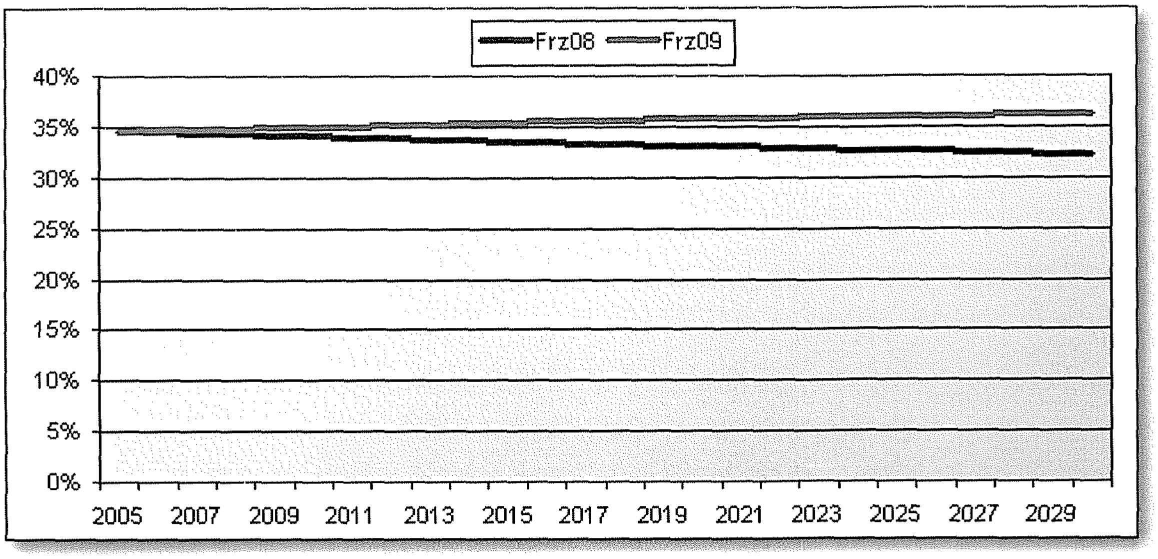


Figure 12: Freezer Saturation Projections (U.S.)

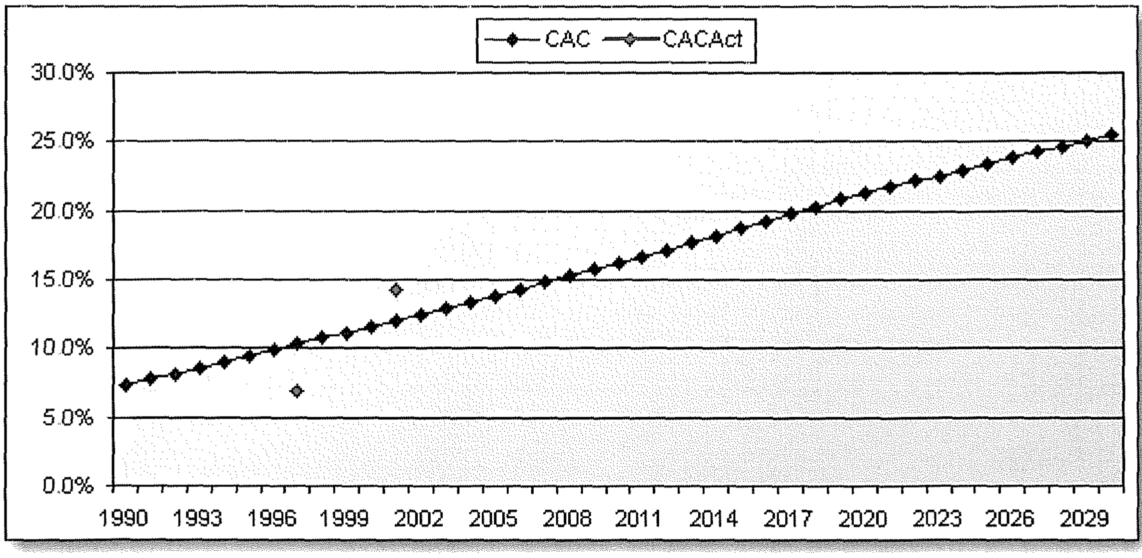


Calibration to Prior Appliance Saturation Surveys

Every four years, the EIA conducts the Residential Energy Consumption Survey (RECS), which is used to collect detailed end-use information, which in turn forms the basis for EIA's Annual Energy Outlook forecast. The 2008 and 2009 forecasts are based on the 2005 RECS. Unfortunately, reported end-use saturations for some end-uses are not always consistent across survey years. To the extent possible, we adjusted the historical saturation rates to reflect reported end-use saturations from earlier surveys. Where the historical survey data does not provide useful information, we assume a linear historical saturation trend.

The problem is illustrated in Figure 13, which shows reported New England central air conditioning saturation for 1997 and 2001 (in red). The blue line shows the 2009 AEO saturation forecast based on the 2005 appliance saturation survey. The 1997 reported saturation is 7.0%, the 2001 reported saturation is 14.2%, and the 2005 reported saturation is 13.7%. In all likelihood, central air conditioning saturation did not decline between 2001 and 2005. In this case, we assumed that central air conditioning saturation over the historical period increased at the same rate as that projected in the forecast.

Figure 13: New England Central Air Conditioning Saturation



Structural Index

The structural index reflects both improvements in thermal shell efficiency and changing housing square footage. Changes in the structural index drive heating and cooling use through its interaction with the heating and cooling efficiency and saturation trends (See Appendix A). While there is little change in thermal shell efficiency from the 2008 forecast, square footage growth is stronger. Figure 14 compares expected average square footage growth across all regions and Figure 15 and Figure 16 compare the resulting change in the heating and cooling structural indices.

Figure 14: Annual Square Footage Growth Projections (U.S.)

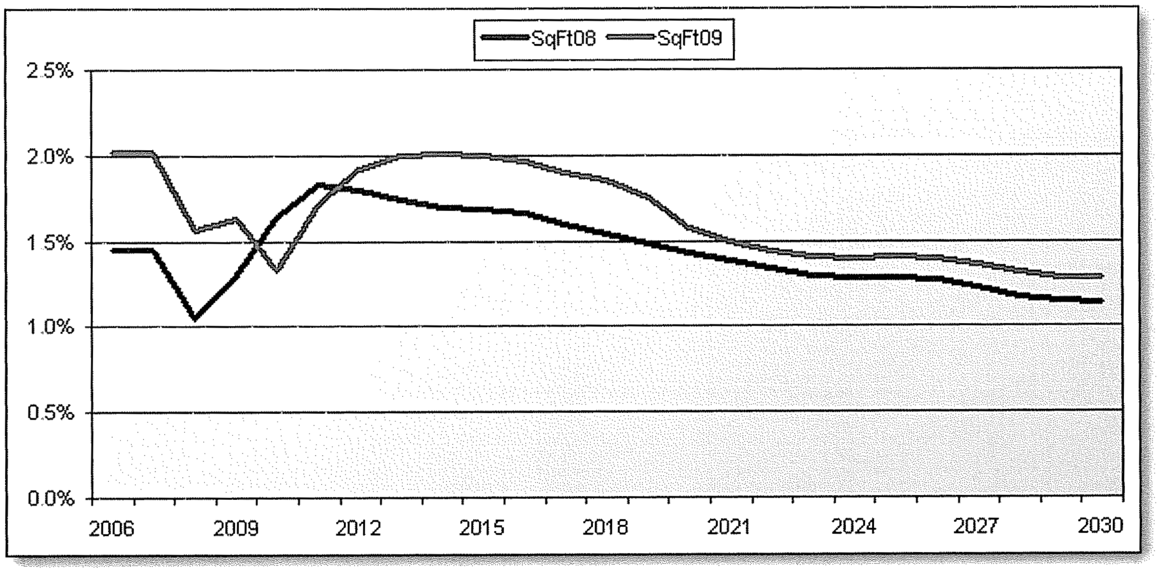


Figure 15: Structural Index Growth Projections – Heating (U.S.)

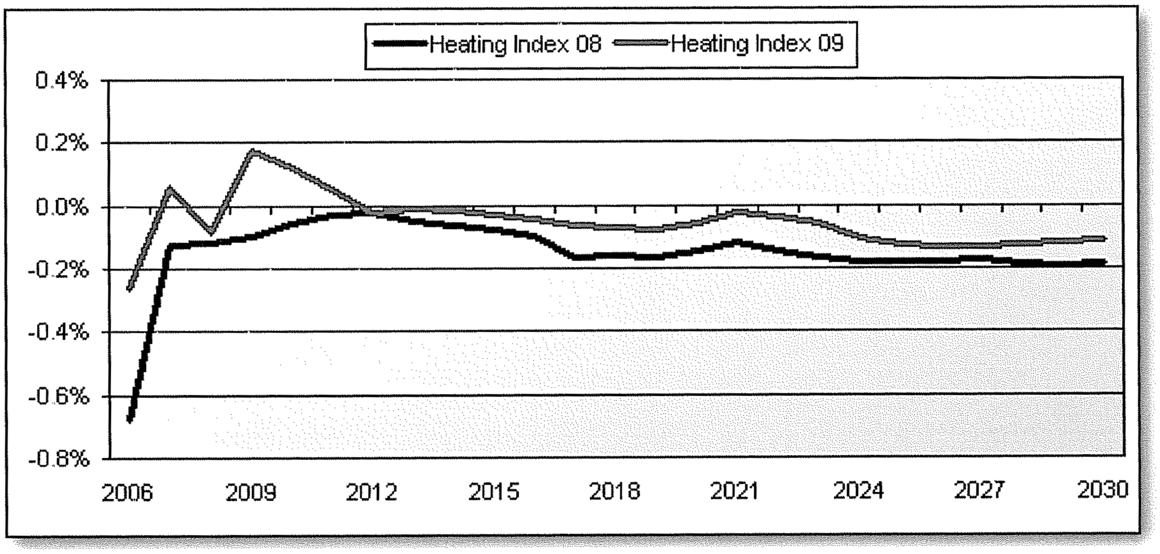
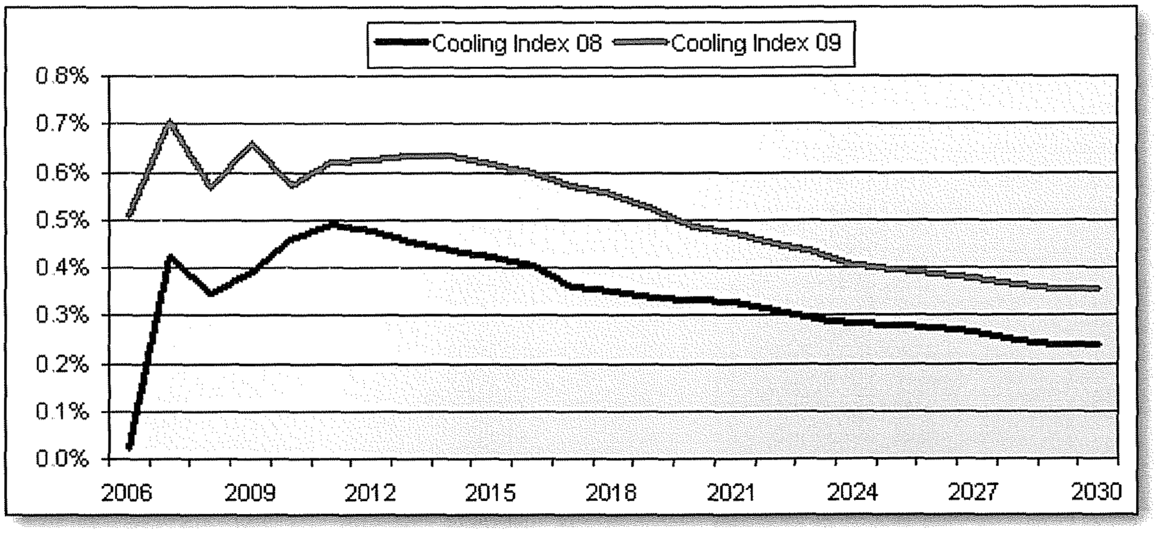


Figure 16: Structural Index Growth Projections – Cooling (U.S.)



SAE Model Indices

End-use saturation, efficiency, and structural index projections are used to construct end-use use indices (kWh/year) for heating, cooling, and other uses. The annual indices are in turn used to construct monthly end-use energy variables (XHeat, XCool, and XOther), which are used in estimating the SAE average use models. Appendix A describes how the annual indices and monthly end-use energy variables are constructed.

Heating

The 2009 heating index is somewhat lower than in the 2008 forecast largely as a result of a lower secondary heat saturation rate. The new heat index is flat through 2017, and then tracks the 2008 forecasted growth rate after 2017. Figure 17 shows the 2009 and 2008 annual heating index across all Census Divisions. Figure 18 compares annual index growth rate.

Figure 17: Annual U.S. Heating Index (kWh/year)

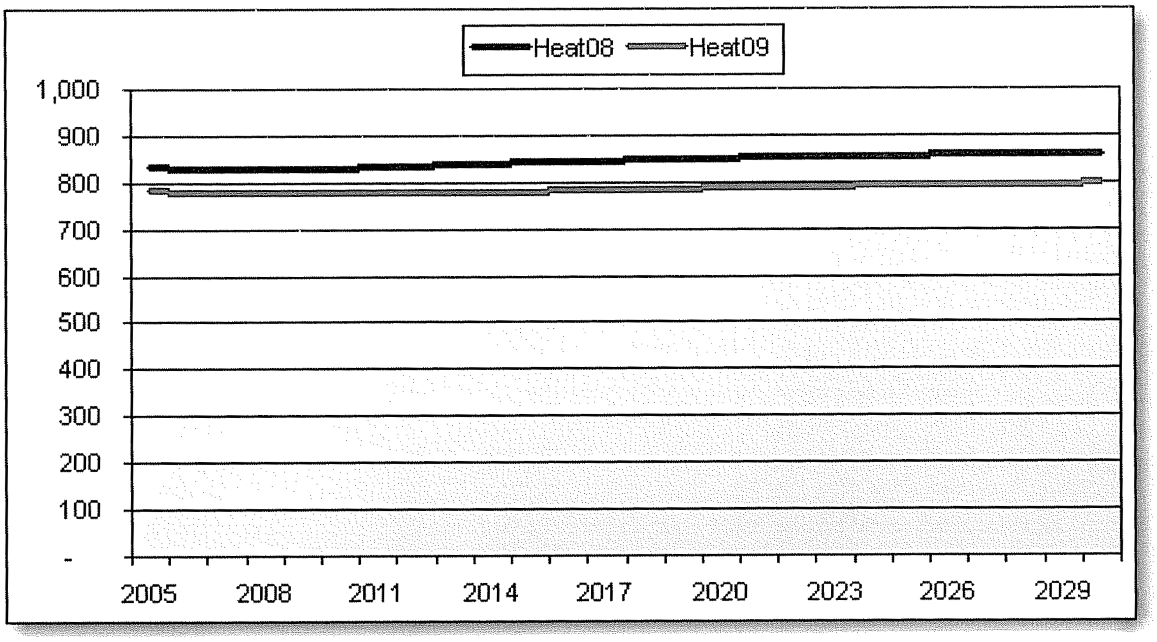
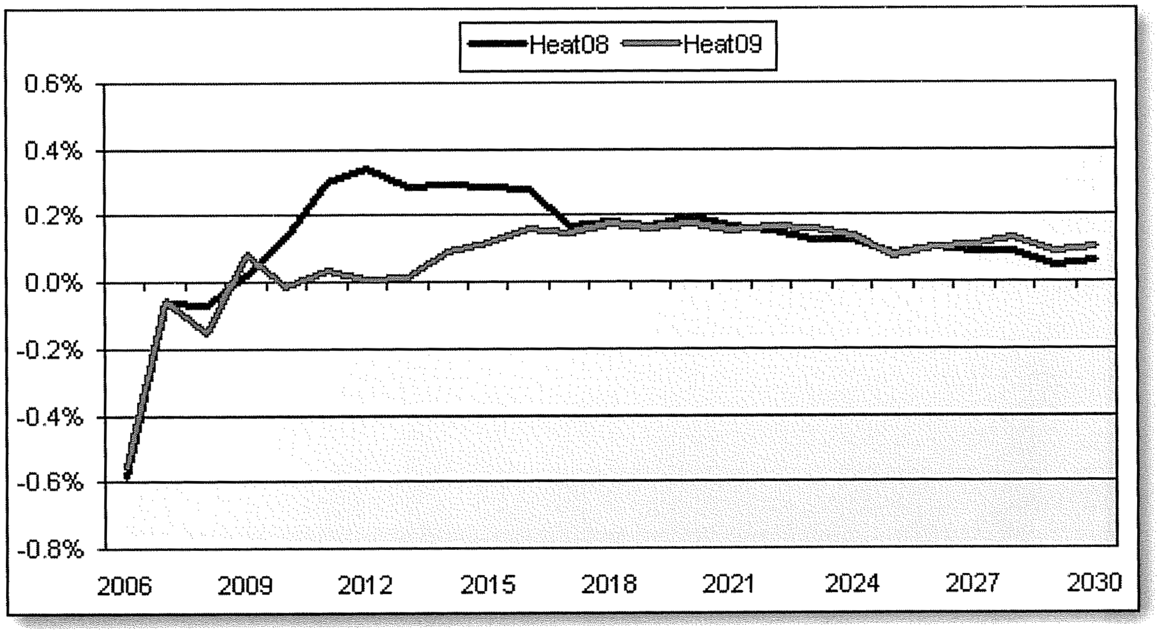


Figure 18: Change in U.S. Heating Index



Cooling

Figure 19 compares forecasted cooling indices on a national basis. Not only is the 2009 cooling index higher in the 2005 base year, but it increases at a faster rate when compared with the 2008 cooling index. The starting average square footage assumption is higher than in the 2008 forecast and increases at a faster rate than in the prior forecast. Figure 20 compares the annual changes in cooling index projections.

Figure 19: Annual U.S. Cooling Index (kWh/year)

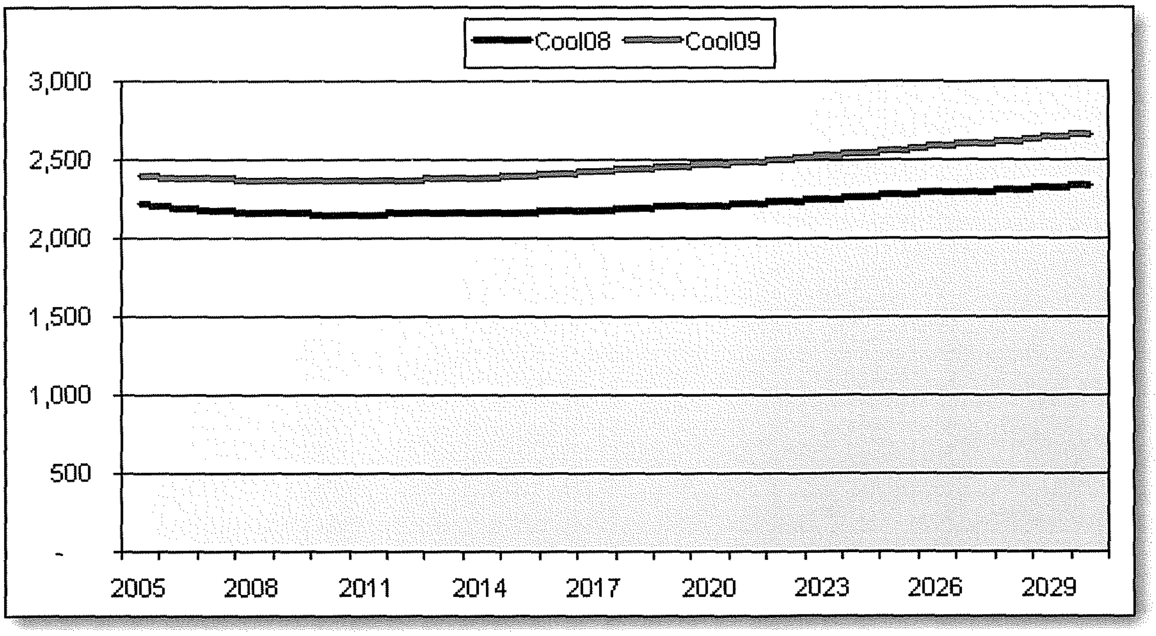
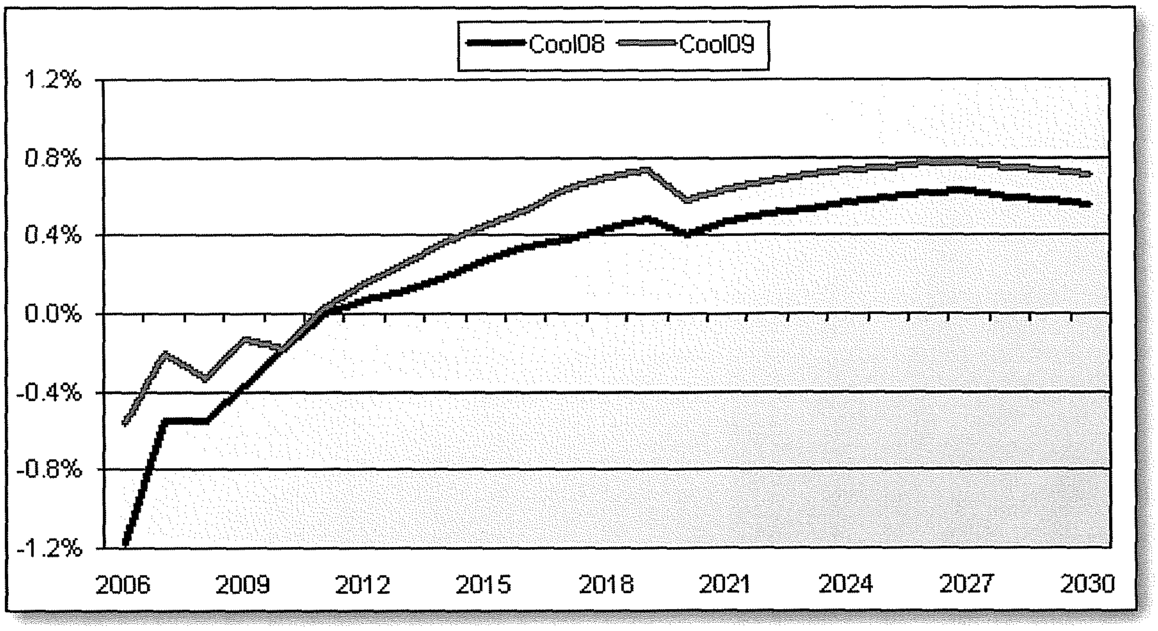


Figure 20: Change in U.S. Cooling Index



Other End-Uses

The 2009 other use index is flat to declining through 2012, as the new forecast assumes faster adoption of CFLs. As a result, the drop in the other use index is not as severe in 2012. The 2009 other use index drops less than 2% in 2013 compared with a forecasted drop of over 3% in the 2008 forecast. Over the long-term, the new other index forecast increases as a slightly lower rate than in the 2008 forecast. Figure 21 compares 2008 and 2009 base use indices and Figure 22 compares their annual growth rates.

Figure 21: Other End-Use Index (kWh/year)

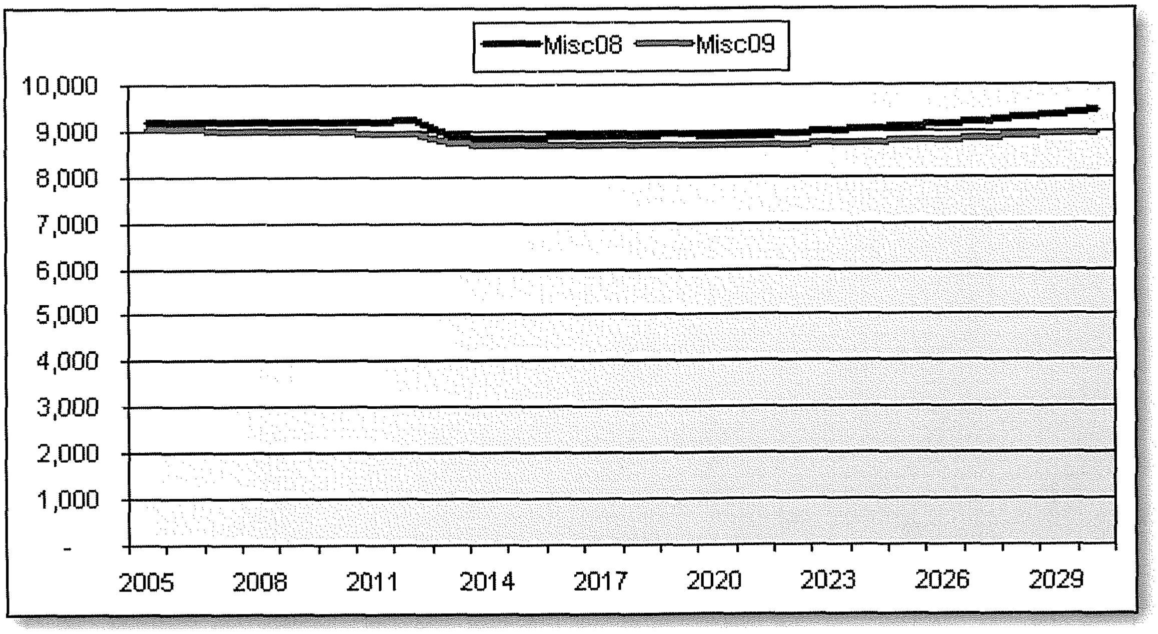
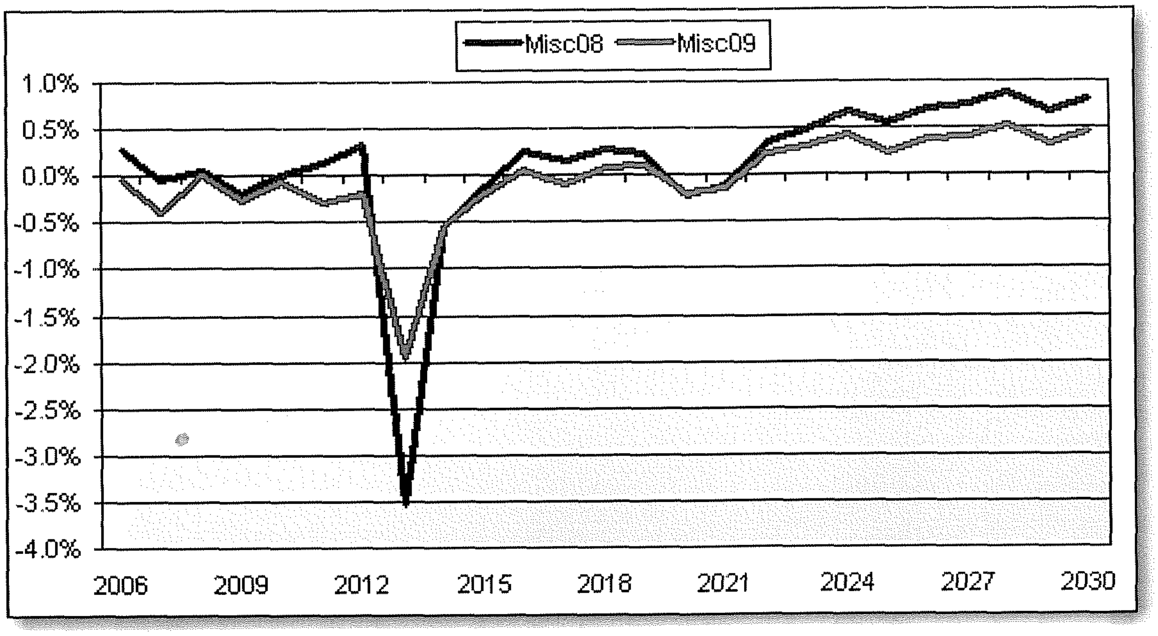


Figure 22: Change in Other End-Use Index (kWh/year)



Residential Average Use Forecast

The constructed end-use variables are used to estimate SAE average use models and to generate residential average use forecasts. The forecast reflects not only changes in the end-use indices, but also normal weather, price and economic projections. Separate *MetrixND* models are estimated for each Census Division and for the U.S. Figure 23 compares the 2009 and 2008 average use forecasts and Figure 24 compares their annual growth rates.

Figure 23: Residential Average Use Forecast (kWh/year)

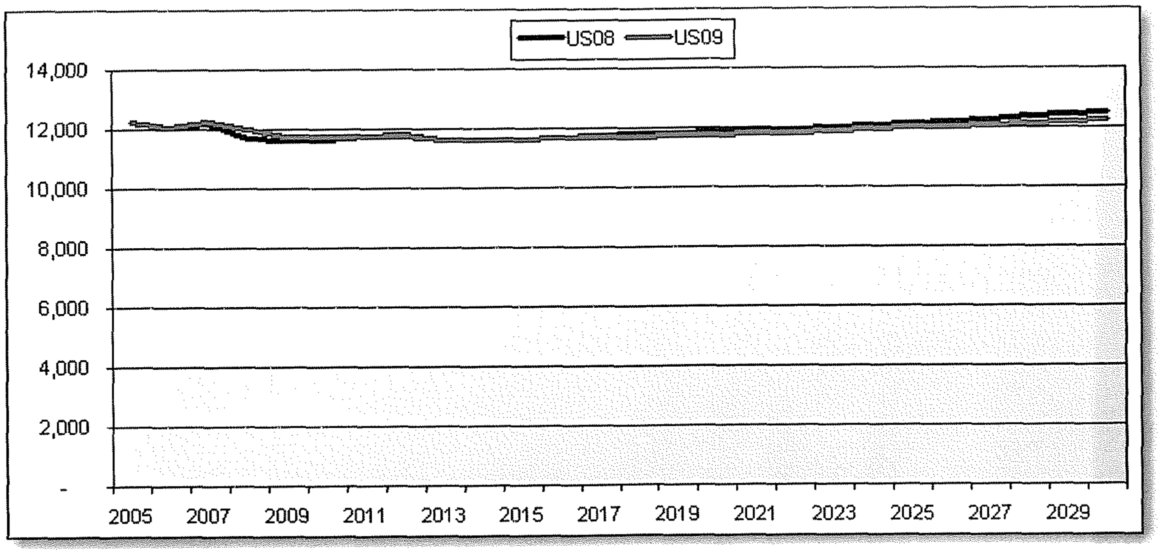
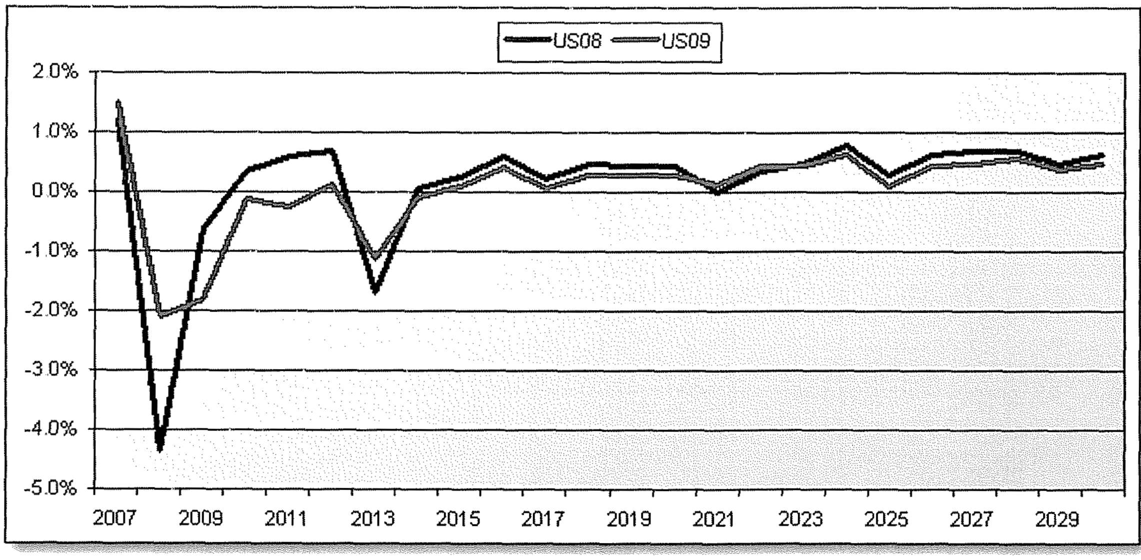


Figure 24: Change in Residential Average Use



The 2009 average use forecast is slightly lower than in the 2008 forecast, as it reflects a less optimistic economic outlook. Average use declines slightly through the near-term, but does not drop as sharply in 2013, as the lighting standards take effect. While 2009 air conditioning usage is stronger than in the 2008 forecast, miscellaneous usage growth is weaker. The net effect is that after 2014, average use increases at rate just slightly lower than last year's forecast.

Appendix A: Residential SAE Modeling Framework

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, the strength of econometric models is that they are well suited to identifying historical trends and to projecting these trends into the future. In contrast, the strength of the end-use modeling approach is the ability to identify the end-use factors that are driving energy use. By incorporating end-use structure into an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to this approach.

- The equipment efficiency and saturation trends, dwelling square footage, and thermal integrity changes embodied in the long-run end-use forecasts are introduced explicitly into the short-term monthly sales forecast. This provides a strong bridge between the two forecasts.
- By explicitly introducing trends in equipment saturations, equipment efficiency, dwelling square footage, and thermal integrity levels, it is easier to explain changes in usage levels and changes in 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 incorporated into the final model.

This section describes this approach, the associated supporting SAE spreadsheets, and the *MetrixND* project files that are used in the implementation. The source for the majority of the SAE spreadsheets is the 2009 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

Statistically Adjusted End-Use Modeling 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,

$$USE_{y,m} = Heat_{y,m} + Cool_{y,m} + Other_{y,m} \qquad (1)$$

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

- Heating degree days
- Heating equipment saturation levels
- Heating equipment operating efficiencies
- Average number of days in the billing cycle for each month
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

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

$$XHeat_{y,m} = HeatIndex_{y,m} \times HeatUse_{y,m} \quad (3)$$

Where:

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

The heating equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Given a set of fixed weights, the index will change over time with changes in equipment saturations (*Sat*), operating efficiencies (*Eff*), building structural index (*StructuralIndex*), and energy prices. Formally, the equipment index is defined as:

$$HeatIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{05}^{Type} \big/ Eff_{05}^{Type} \right)} \tag{4}$$

The *StructuralIndex* is constructed by combining the EIA's building shell efficiency index trends with surface area estimates, and then it is indexed to the 2005 value:

$$StructuralIndex_y = \frac{BuildingShellEfficiencyIndex_y \times SurfaceArea_y}{BuildingShellEfficiencyIndex_{05} \times SurfaceArea_{05}} \tag{5}$$

The *StructuralIndex* is defined on the *StructuralVars* tab of the SAE spreadsheets. Surface area is derived to account for roof and wall area of a standard dwelling based on the regional average square footage data obtained from EIA. The relationship between the square footage and surface area is constructed assuming an aspect ratio of 0.75 and an average of 25% two-story and 75% single-story. Given these assumptions, the approximate linear relationship for surface area is:

$$SurfaceArea_y = 892 + 1.44 \times Footage_y \tag{6}$$

In Equation 4, 2005 is used as a base year for normalizing the index. As a result, the ratio on the right is equal to 1.0 in 2005. In other years, it will be greater than 1.0 if equipment saturation levels are above their 2005 level. This will be counteracted by higher efficiency levels, which will drive the index downward. The weights are defined as follows.

$$Weight^{Type} = \frac{Energy_{05}^{Type}}{HH_{05}} \times HeatShare_{05}^{Type} \tag{7}$$

In the SAE spreadsheets, these weights are referred to as *Intensities* and are defined on the *EIAData* tab. With these weights, the *HeatIndex* value in 2005 will be equal to estimated annual heating intensity per household in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

For electric heating equipment, the SAE spreadsheets contain two equipment types: electric resistance furnaces/room units and electric space heating heat pumps. Examples of weights for these two equipment types for the U.S. are given in Table 1.

Table 1: Electric Space Heating Equipment Weights

Equipment Type	Weight (kWh)
Electric Resistance Furnace/Room units	505
Electric Space Heating Heat Pump	190

Data for the equipment saturation and efficiency trends are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for electric space heating heat pumps are given in terms of Heating Seasonal Performance Factor [BTU/Wh], and the efficiencies for electric furnaces and room units are estimated as 100%, which is equivalent to 3.41 BTU/Wh.

Price Impacts. In the 2009 Version of the SAE models, the Heat Index has been extended to account for the long-run impact of electric and natural gas prices. Since the Heat Index represents changes in the stock of space heating equipment, the price impacts are modeled to play themselves out over a ten year horizon. To introduce price effects, the Heat Index as defined by Equation 4 above is multiplied by a 10 year moving average of electric and gas prices. The level of the price impact is guided by the long-term price elasticities. Formally,

$$HeatIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \Big/ Eff_y^{Type} \right)}{\left(Sat_{05}^{Type} \Big/ Eff_{05}^{Type} \right)} \times \left(TenYearMovingAverageElectricPrice_{y,m} \right)^{\phi} \times \left(TenYearMovingAverageGasPrice_{y,m} \right)^{\gamma} \quad (8)$$

Since the trends in the Structural index (the equipment saturations and efficiency levels) are provided exogenously by the EIA, the price impacts are introduced in a multiplicative form. As a result, the long-run change in the Heat Index represents a combination of adjustments to the structural integrity of new homes, saturations in equipment and efficiency levels relative to what was contained in the base EIA long-term forecast.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, prices, and billing days. The estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{WgtHDD_{y,m}}{HDD_{05}}\right) \times \left(\frac{HHSize_{y}}{HHSize_{05}}\right)^{0.25} \times \left(\frac{Income_{y}}{Income_{05}}\right)^{0.20} \times \left(\frac{ElecPrice_{y,m}}{ElecPrice_{05,7}}\right)^{\lambda} \times \left(\frac{GasPrice_{y,m}}{GasPrice_{05,7}}\right)^{\kappa} \quad (9)$$

Where:

- *BDays* is the number of billing days in year (y) and month (m), these values are normalized by 30.5 which is the average number of billing days
- *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 2005
- *HHSize* is average household size in a year (y)
- *Income* is average real income per household in year (y)
- *ElecPrice* is the average real price of electricity in month (m) and year (y)
- *GasPrice* is the average real price of natural gas 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 (2005). The first two terms, which involve billing days and heating 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 reflect changes in the economic drivers, as transformed through the end-use elasticity parameters. The price impacts captured by the Usage equation represent short-term price response.

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 equipment saturation levels
- Cooling equipment operating efficiencies
- Average number of days in the billing cycle for each month
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

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

$$XCool_{y,m} = CoolIndex_{y} \times CoolUse_{y,m} \tag{10}$$

Where

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

As with heating, the cooling equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Formally, the cooling equipment index is defined as:

$$CoolIndex_{y} = StructuralIndex_{y} \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_{y}^{Type} \Big/ Eff_{y}^{Type} \right)}{\left(Sat_{05}^{Type} \Big/ Eff_{05}^{Type} \right)} \tag{11}$$

Data values in 2005 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2005. In other years, it will be greater than 1.0 if equipment saturation levels are above their 2005 level. This will be counteracted by higher efficiency levels, which will drive the index downward. The weights are defined as follows.

$$Weight^{Type} = \frac{Energy_{05}^{Type}}{HH_{05}} \times CoolShare_{05}^{Type} \tag{12}$$

In the SAE spreadsheets, these weights are referred to as *Intensities* and are defined on the *EIAData* tab. With these weights, the *CoolIndex* value in 2005 will be equal to estimated annual cooling intensity per household in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

For cooling equipment, the SAE spreadsheets contain three equipment types: central air conditioning, space cooling heat pump, and room air conditioning. Examples of weights for these three equipment types for the U.S. are given in Table 2.

Table 2: Space Cooling Equipment Weights

Equipment Type	Weight (kWh)
Central Air Conditioning	1,661
Space Cooling Heat Pump	369
Room Air Conditioning	315

The equipment saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for space cooling heat pumps and central air conditioning (A/C) units are given in terms of Seasonal Energy Efficiency Ratio [BTU/Wh], and room A/C units efficiencies are given in terms of Energy Efficiency Ratio [BTU/Wh].

Price Impacts. In the 2009 SAE models, the Cool Index has been extended to account for changes in electric and natural gas prices. Since the Cool Index represents changes in the stock of space heating equipment, it is anticipated that the impact of prices will be long-term in nature. The Cool Index as defined Equation 11 above is then multiplied by a 10 year moving average of electric and gas prices. The level of the price impact is guided by the long-term price elasticities. Formally,

$$CoolIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{05}^{Type} \big/ Eff_{05}^{Type} \right)} \times \left(TenYearMovingAverageElectricPrice_{y,m}\right)^{\phi} \times \left(TenYearMovingAverageGasPrice_{y,m}\right)^{\gamma} \quad (13)$$

Since the trends in the Structural index, equipment saturations and efficiency levels are provided exogenously by the EIA, price impacts are introduced in a multiplicative form. The long-run change in the Cool Index represents a combination of adjustments to the structural integrity of new homes, saturations in equipment and efficiency levels. Without a detailed end-use model, it is not possible to isolate the price impact on any one of these concepts.

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, and prices. The estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{WgtCDD_{y,m}}{CDD_{05}}\right) \times \left(\frac{HHSize_{y}}{HHSize_{05}}\right)^{0.25} \times \left(\frac{Income_{y}}{Income_{05}}\right)^{0.20} \times \left(\frac{ElecPrice_{y,m}}{ElecPrice_{05}}\right)^{\lambda} \times \left(\frac{GasPrice_{y,m}}{GasPrice_{05}}\right)^{\kappa} \qquad (14)$$

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 2005.

By construction, the *CoolUse* variable has an annual sum that is close to 1.0 in the base year (2005). 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 the economic driver changes.

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:

- Appliance and equipment saturation levels
- Appliance efficiency levels
- Average number of days in the billing cycle for each month
- Average household size, real income, and real prices

The explanatory variable for other uses is defined as follows:

$$XOther_{y,m} = OtherEqpIndex_{y,m} \times OtherUse_{y,m} \qquad (15)$$

The first term on the right hand side of this expression (*OtherEqpIndex*$_y$) embodies information about appliance saturation and efficiency levels and monthly usage multipliers. The second term (*OtherUse*) captures the impact of changes in prices, income, household size, and number of billing-days on appliance utilization.

End-use indices are constructed in the SAE models. A separate end-use index is constructed for each end-use equipment type using the following function form.

$$ApplianceIndex_{y,m} = Weight^{Type} \times \frac{\left(Sat_y^{Type} \Big/ \frac{1}{UEC_y^{Type}} \right)}{\left(Sat_{05}^{Type} \Big/ \frac{1}{UEC_{05}^{Type}} \right)} \times MoMult_m^{Type} \times \tag{16}$$
$$(TenYearMovingAverageElectric\,\Pr ice)^{\lambda} \times (TenYearMovingAverageGas\,\Pr ice)^{\kappa}$$

Where:

- *Weight* is the weight for each appliance type
- *Sat* represents the fraction of households, who own an appliance type
- $MoMult_m$ is a monthly multiplier for the appliance type in month (m)
- *Eff* is the average operating efficiency the appliance
- *UEC* is the unit energy consumption for appliances

This index combines information about trends in saturation levels and efficiency levels for the main appliance categories with monthly multipliers for lighting, water heating, and refrigeration.

The appliance saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets.

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

$$ApplianceUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5} \right) \times \left(\frac{HHSize_y}{HHSize_{05}} \right)^{0.46} \times \left(\frac{Income_y}{Income_{05}} \right)^{0.10} \times \tag{17}$$
$$\left(\frac{Elec\Pr ice_{y,m}}{Elec\Pr ice_{05}} \right)^{\phi} \times \left(\frac{Gas\Pr ice_{y,m}}{Gas\Pr ice_{05}} \right)^{\lambda}$$

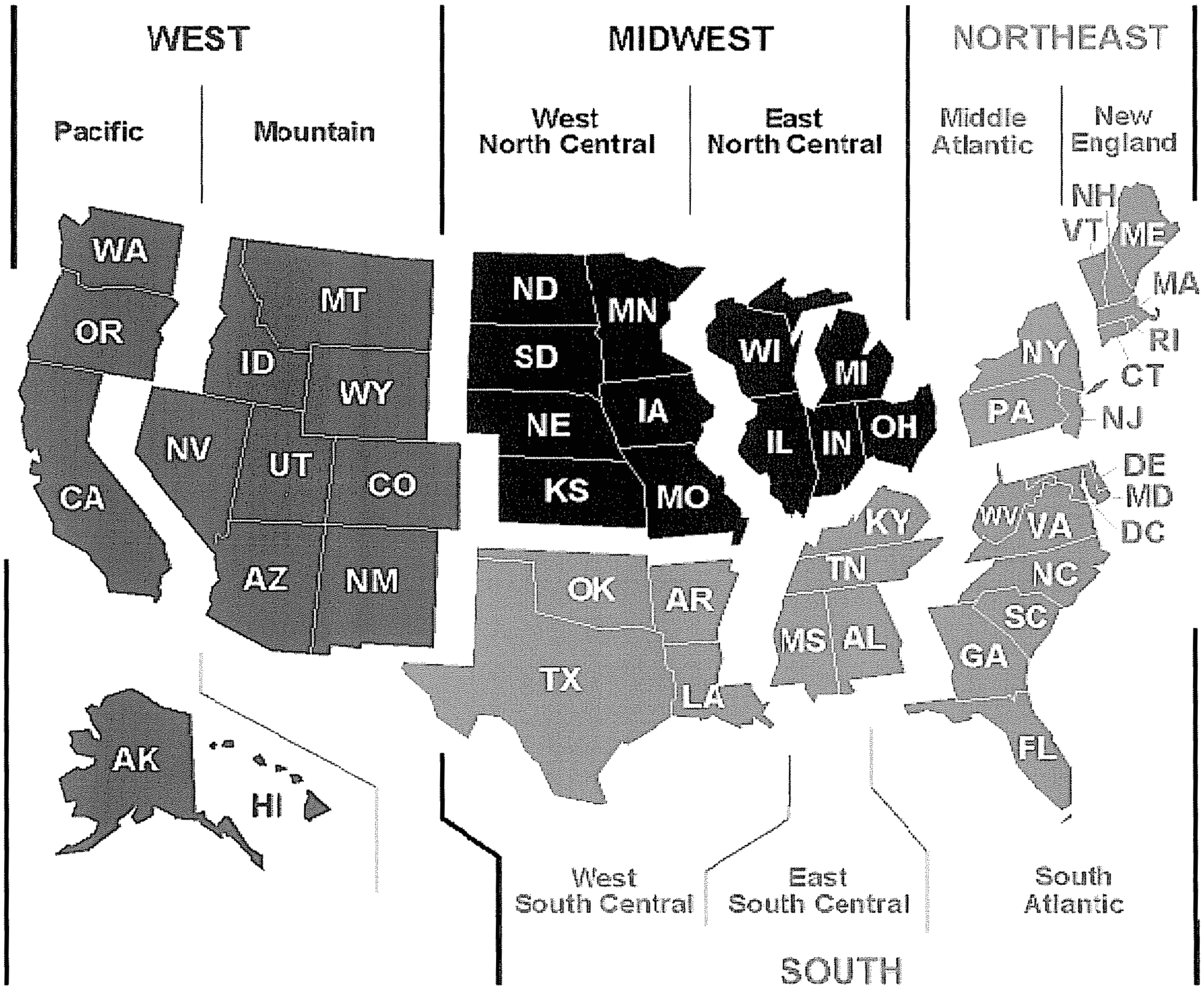
The index for other uses is derived then by summing across the appliances:

$$OtherEqpIndex_{y,m} = \sum_{k} ApplianceIndex_{y,m} \times ApplianceUse_{y,m} \qquad (18)$$

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 25. 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 3.

Figure 25: Mapping of States to Census Divisions



Source: http://www.eia.doe.gov/emeu/reps/maps/us_census.html

Table 3: List of SAE Files

Spreadsheet	*MetrixND* Project File
NewEngland.xls	SAE_NewEngland.ndm
MiddleAtlantic.xls	SAE_MiddleAtlantic.ndm
EastNorthCentral.xls	SAE_EastNorthCentral.ndm
WestNorthCentral.xls	SAE_WestNorthCentral.ndm
SouthAtlantic.xls	SAE_SouthAltantic.ndm
EastSouthCentral.xls	SAE_EastSouthCentral.ndm
WestSouthCentral.xls	SAE_WestSouthCentral.ndm
Mountain.xls	SAE_Mountain.ndm
Pacific.xls	SAE_Pacific.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 *MetrixND* project files are linked to the data in these spreadsheets. In these project files, the end-use *Usage* variables are constructed and the SAE model is estimated.

Each of the nine SAE spreadsheets contains the following tabs.

- **Definitions.** Contains equipment, end use, worksheet, and Census Division definitions.
- **AnnualIndices.** Contains the annual *Heat*, *Cool* and *Other* equipment indices.
- **ShareUEC.** Calculates the annual equipment indices.
- **Shares.** Contains historical and forecasted equipment shares. The default forecasted values are provided by the EIA. The raw EIA projections are provided on the *EIAData* tab.
- **Efficiencies.** Contains historical and forecasted equipment efficiency trends. The forecasted values are based on projections provided by the EIA. The raw EIA projections are provided on the *EIAData* tab.
- **StructuralVars.** Contains historical and forecasted square footage, number of households, building shell efficiency index, and calculation of structural variable. The forecasted values are based on projections provided by the EIA.
- **EIAData.** Contains the raw forecasted data provided by the EIA. This tab also contains calculations of the base year *Intensity* values used to weight the equipment indices.
- **MonthlyMults.** Contains monthly multipliers that are used to spread the annual equipment indices across the months.

The *MetrixND* Project files are linked to the *AnnualIndices*, *ShareUEC*, and *MonthlyMults* tabs in the spreadsheets. Sales, economic, price and weather information for the Census Division is provided in the linkless data table *UtilityData*. In this way, utility specific data and the equipment indices are brought into the project file. The *MetrixND* project files contain the objects described below.

Parameter Tables

- **Elas.** This parameter table includes the values of the elasticities used to calculate the *Usage* variables for each end-use. There are five types of elasticities included on this table.

  - Economic variable elasticities
  - Short-term own price elasticities
  - Short-term cross price elasticities
  - Long-term own price elasticities
  - Long-term cross price elasticities

  The short-term price elasticities drive the end-use usage equations. The long-term price elasticities drive the Heat, Cool and other appliance indices. The combined price impact is an aggregation of the short- and long-term price elasticities. As such, the long-term price elasticities are input as incremental price impact. That is, the long-term price elasticity is the difference between the overall price impact and the short-term price elasticity.

Data Tables

- **AnnualEquipmentIndices.** This data table is linked to the *AnnualIndices* tab for heating and cooling indices, and *ShareUEC* tab for water heating, lighting, and appliances in the SAE spreadsheet.
- **UtilityData.** This is a linkless data table that contains sales, price, economic and weather data specific to a given Census Division.
- **MonthlyMults.** This data table is linked to the corresponding tab in the SAE spreadsheet.

Transformation Tables

- **EconTrans.** This transformation table is used to compute the average usage, and household size, household income, 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.
- **ResidentialVars.** 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.
- **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 is used to compute the monthly sales forecasts by end uses.

Models

- **ResModel:** This is the Statistically Adjusted End-Use Model.

Steps to Customize the Files for Your Service Territory

The files that are included in this package contain regional data. If you have more accurate data for your service territory, you are encouraged to tailor the spreadsheets with that information. This section describes the steps needed to customize the files.

Minimum Customization

- Save the *MetrixND* project file and the spreadsheet into the same folder
- Select the spreadsheet and *MetrixND* project file from the appropriate Census Division
- Open the spreadsheet and navigate to the *EIAData* tab
- In cell "AP24", replace base year Census Division use per customer with observed use per customer for your service territory
- Save the spreadsheet and open the *MetrixND* project file
- Click on the *Update All Links* button on the *Menu* bar
- Review the model results

Customizing the End-use Share Paths

In addition to the minimum steps listed above, you can install your own share history and forecasts. To do this, navigate to the *Share* tab in the spreadsheet and paste in the values for your region.

Customizing the End-use Efficiency Paths

Finally, you can override the end-use efficiency paths that are contained on the *Efficiencies* tab of the spreadsheet.

Attachment to Question No. 1

2009 Commercial Electric Statistically Adjusted End-use (SAE) Spreadsheets

Witness: Schram

2009 Commercial Electric
Statistically Adjusted End-Use (SAE) Spreadsheets

The 2009 Commercial SAE spreadsheets and models have been updated to reflect the Energy Information Agency's (EIA) most recent Annual Energy Outlook (AEO). This forecast reflects both the expected impacts of the 2007 Energy Independence and Security Act (EISA) and 2009 American Recovery and Reinvestment Act (ARRA). Elements that have been updated include:

- End-use energy intensity projections
- End-use efficiency projections
- End-use saturation projections
- Census division commercial SAE project files (MetrixND)

1.1 Energy Intensity Forecast Update

The primary factor driving the commercial indices are the long-term end-use energy intensity projections. Commercial energy intensity is measured in terms of energy use per square foot. The end-use energy intensities incorporate end-use efficiency trends, increase in end-use saturation, and change in long-term term usage driven by price, and economic conditions. Commercial energy intensities are calculated for each of the primary end-uses:

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

Energy intensities are calculated from the Annual Energy Outlook (AEO) commercial database. End-use intensity projections are derived for eleven building types across nine Census Divisions. The energy intensity (EI) is derived by dividing end-use electricity consumption projections by square footage:

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

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

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

$$EI_{ct} = \sum_{b} EI_{bct} * (sqft_{bt} / \sum_{b} sqft_{bt})$$

This year there are relatively significant changes in end-use intensity and efficiency projections. These changes are based on the 2003 Commercial Building Energy Consumption Survey (CBECS) and work carried out by Navigant Consulting evaluating specific end-use efficiencies.

Figure 1 through Figure 8 compare EIA energy intensity projections for selected end-uses. The intensities are weighted across all Census Divisions and reflect aggregate US intensity trends. The most current projections are depicted in **red**, and the last year's projections are shown in **blue**.

Figure 1: Heating Intensity 2008 vs. 2009 (kWh/sqft)

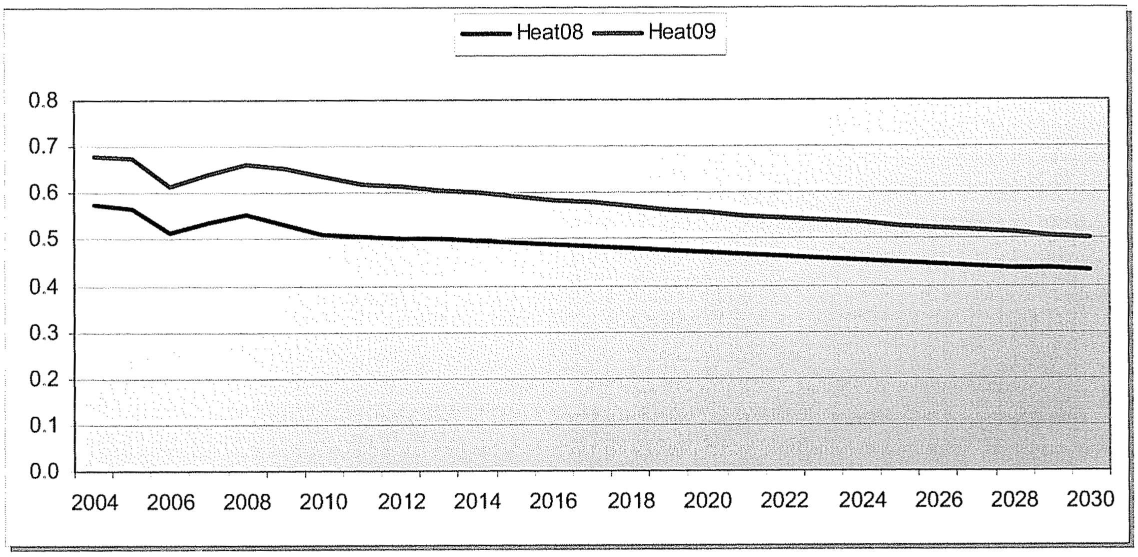


Figure 2: Cooling Intensity 2008 vs. 2009 (kWh/sqft)

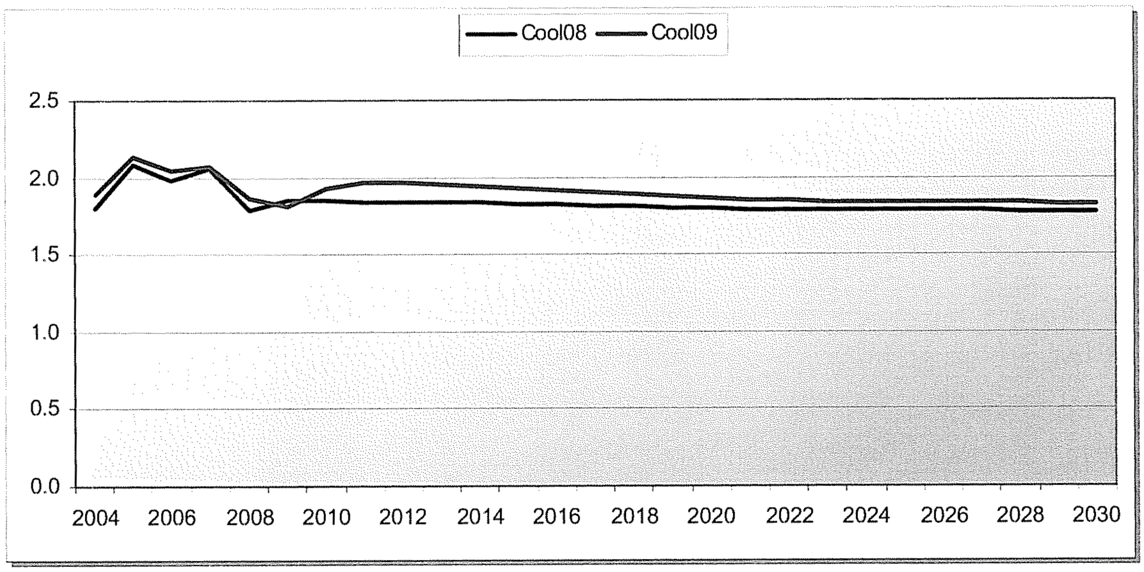


Figure 3: Ventilation Intensity 2008 vs. 2009 (kWh/sqft)

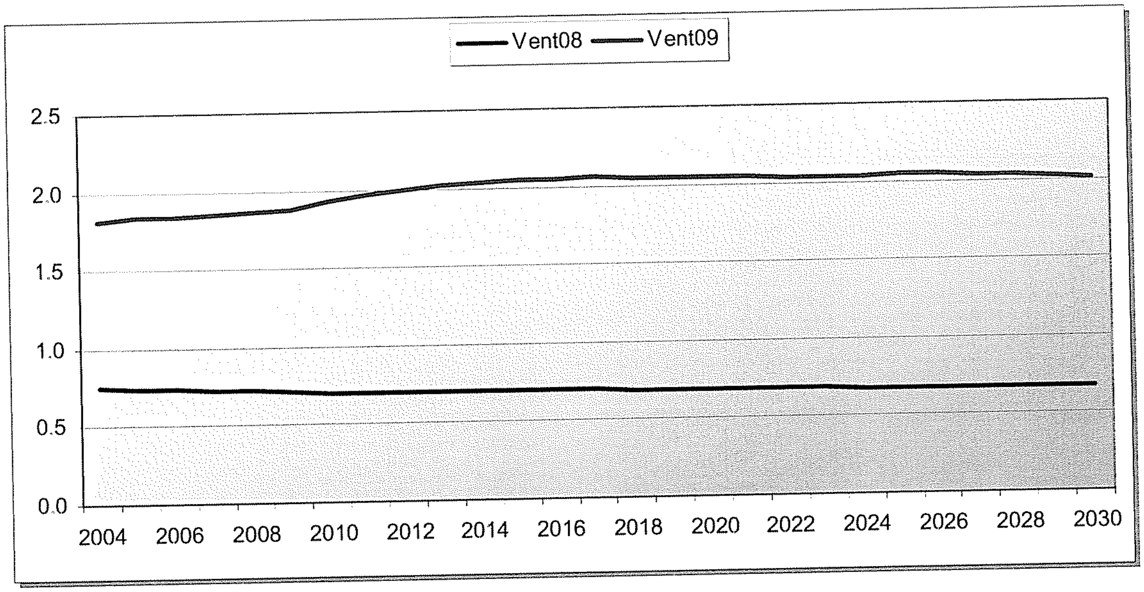


Figure 4: Refrigeration Intensity 2008 vs. 2009 (kWh/sqft)

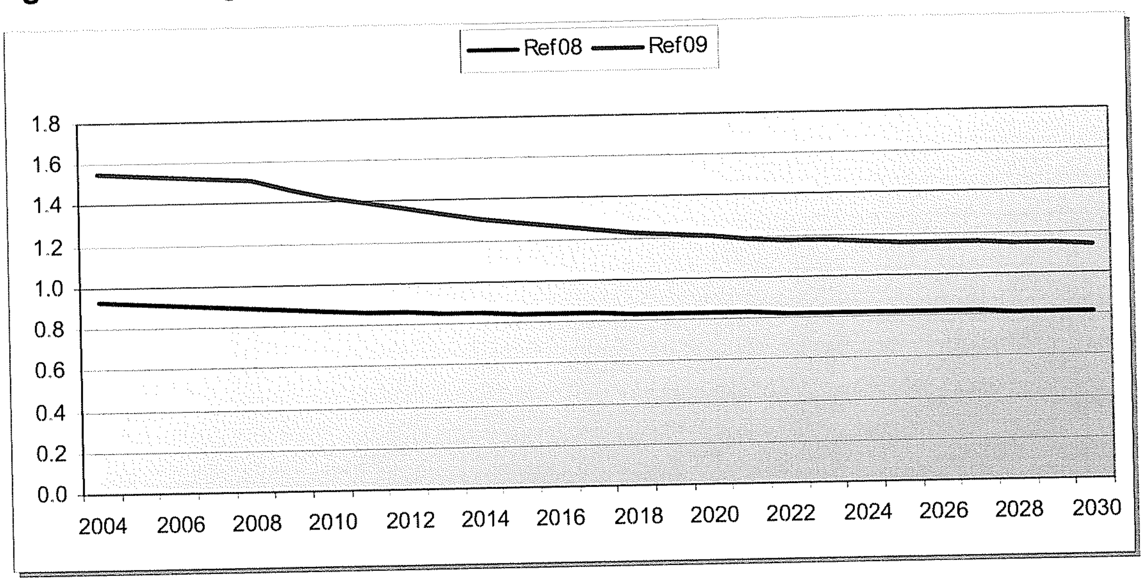


Figure 5: Water Heating Intensity 2008 vs. 2009 (kWh/sqft)

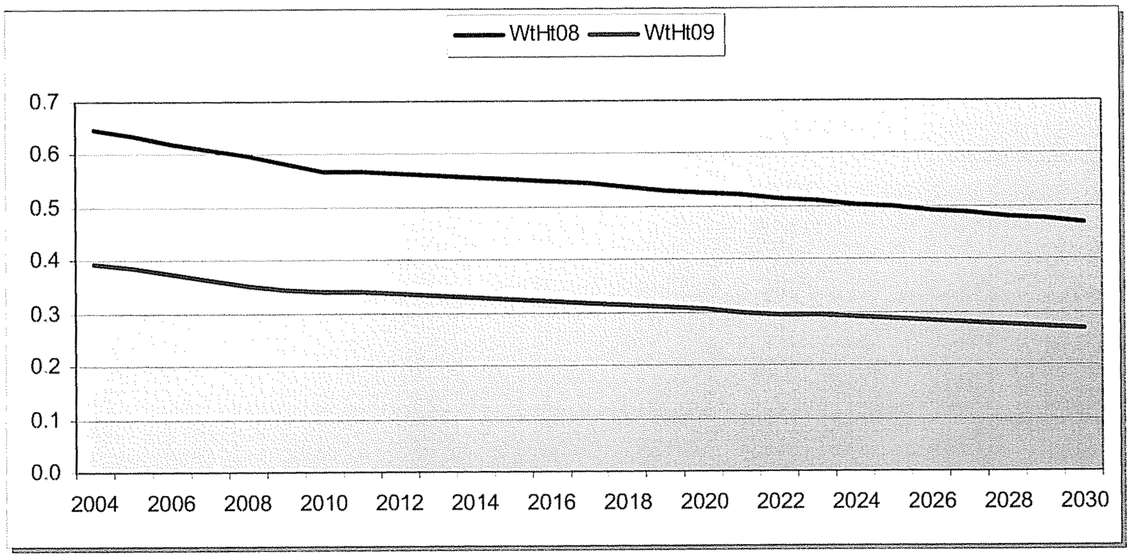


Figure 6: Indoor Lighting Intensity 2008 vs. 2009 (kWh/sqft)

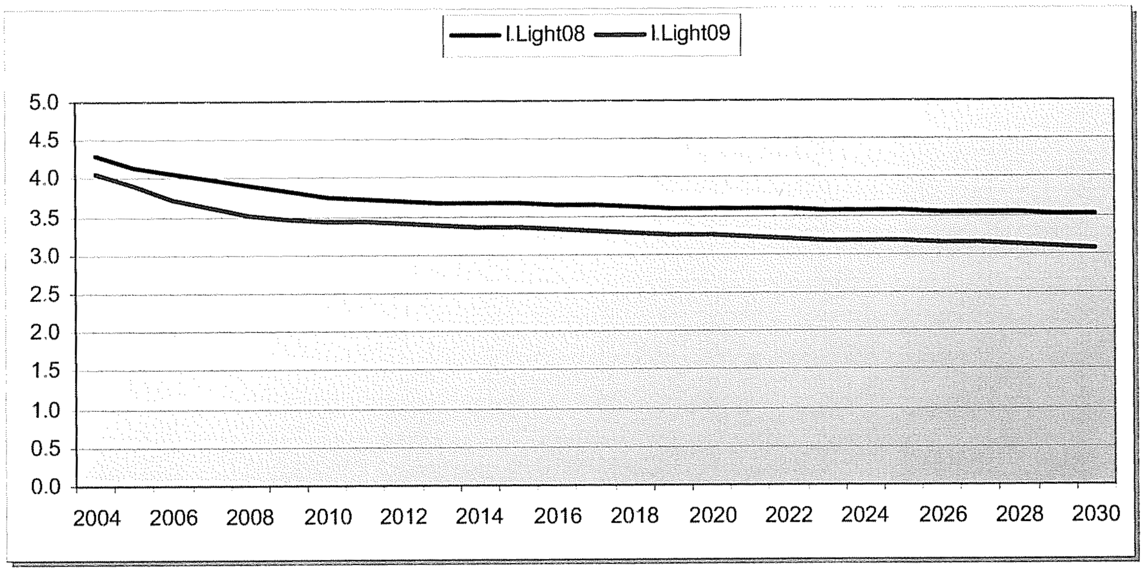


Figure 7: Office Equipment Intensity 2008 vs. 2009 (kWh/sqft)

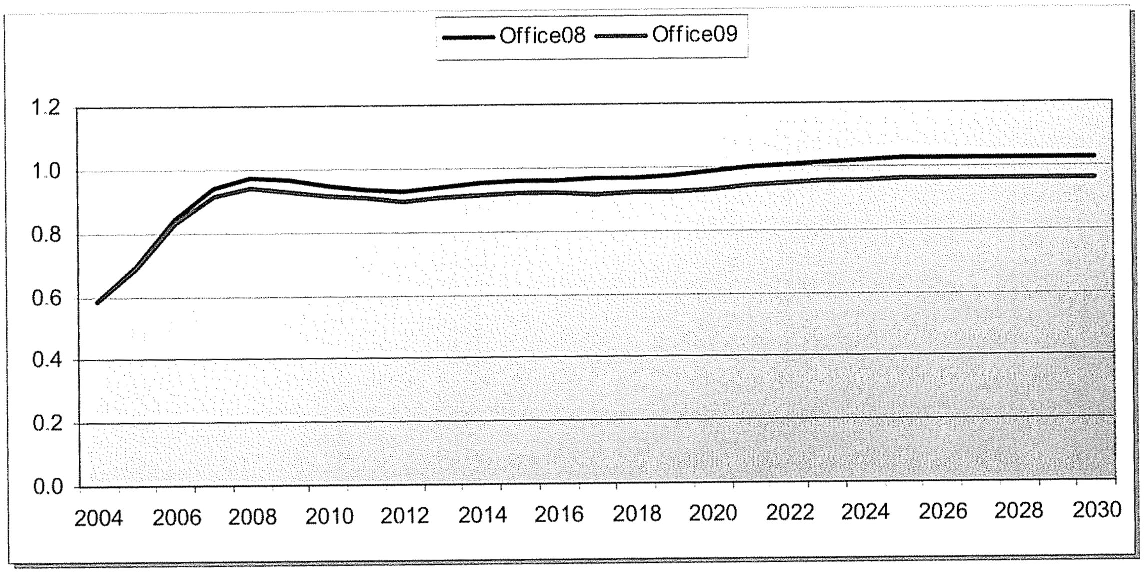
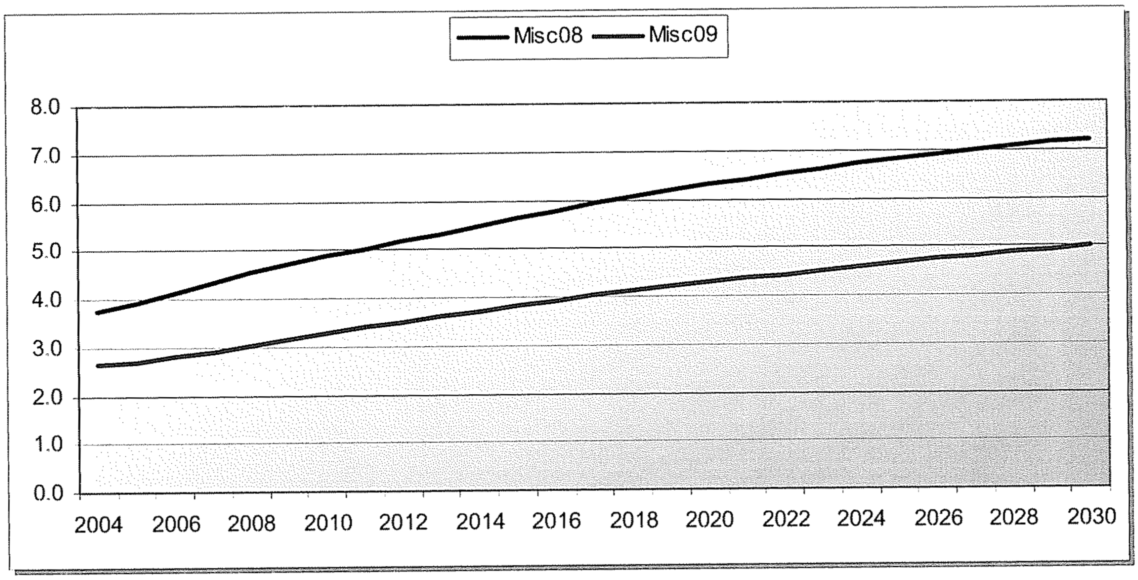
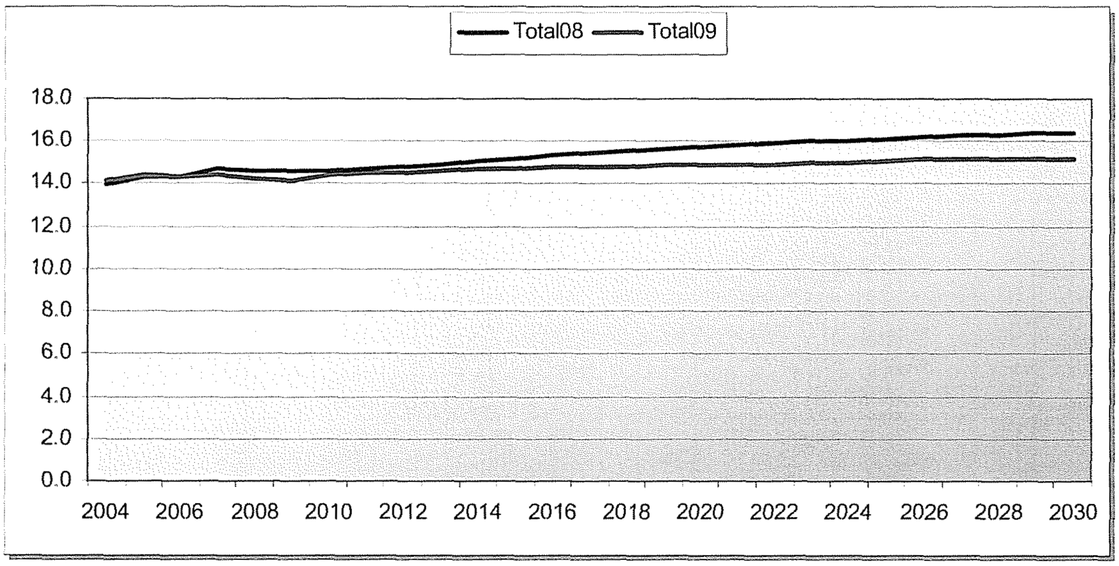


Figure 8: Miscellaneous Equipment Intensity 2008 vs. 2009 (kWh/sqft)



In the 2009 update, heating, cooling, ventilation, refrigeration, and cooking energy intensities are higher while water heating, lighting, office, and miscellaneous equipment intensities are lower. Figure 9 compares total building energy intensities.

Figure 9: Total Commercial Energy Intensity 2008 vs. 2009 (kWh/sqft)



Total commercial energy intensity is lower than the 2008 forecast. Commercial intensity averages 0.5% growth over the next ten years (2009 to 2019) compared with last year's forecast of 0.7% growth. Lower overall intensity reflects change in end-use mix, slightly higher end-use efficiency projections, and higher long-term price projections.

1.2 End-Use Efficiency Forecast Update

Overall commercial end-use efficiency projections are somewhat higher than the 2008 forecasts. Efficiency projections reflect Navigant Consulting recent technology forecast update conducted for the EIA. Heating, cooling, and water heating efficiency projections increase at a slightly faster rate than last year's forecasts while cooking efficiency projections are unchanged. Figure 10 through Figure 13 compare efficiency projections for these end-uses.

Figure 10: Heating Efficiency 2008 vs. 2009 (Btu output/Btu input)

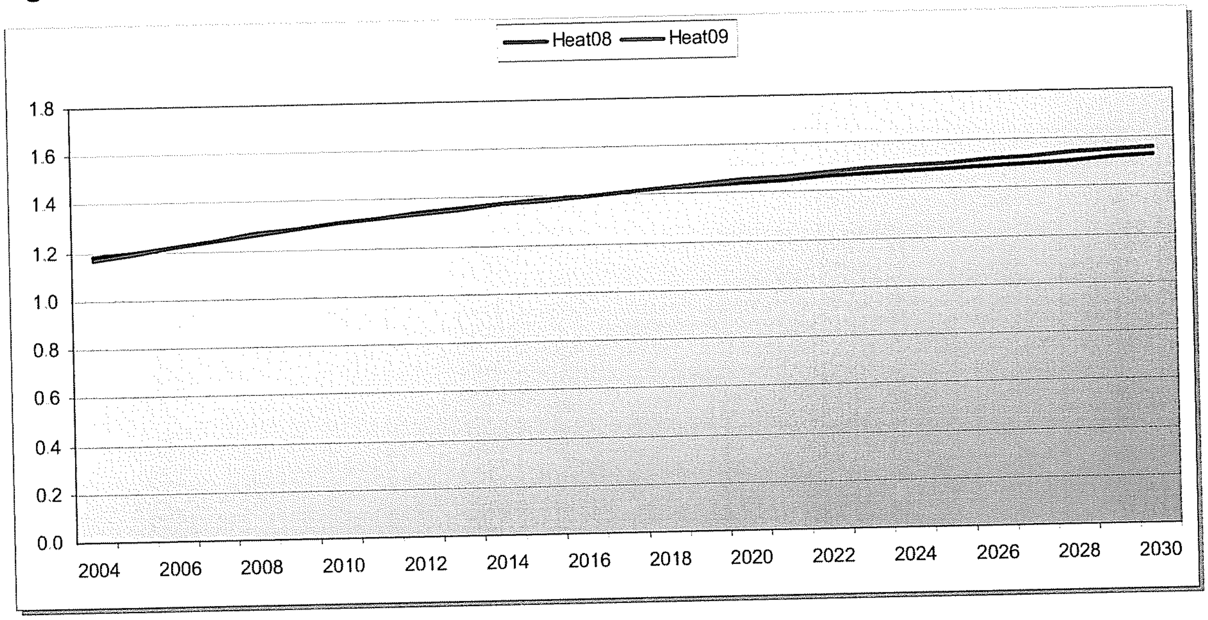


Figure 11: Cooling Efficiency 2008 vs. 2009 (Btu output/Btu input)

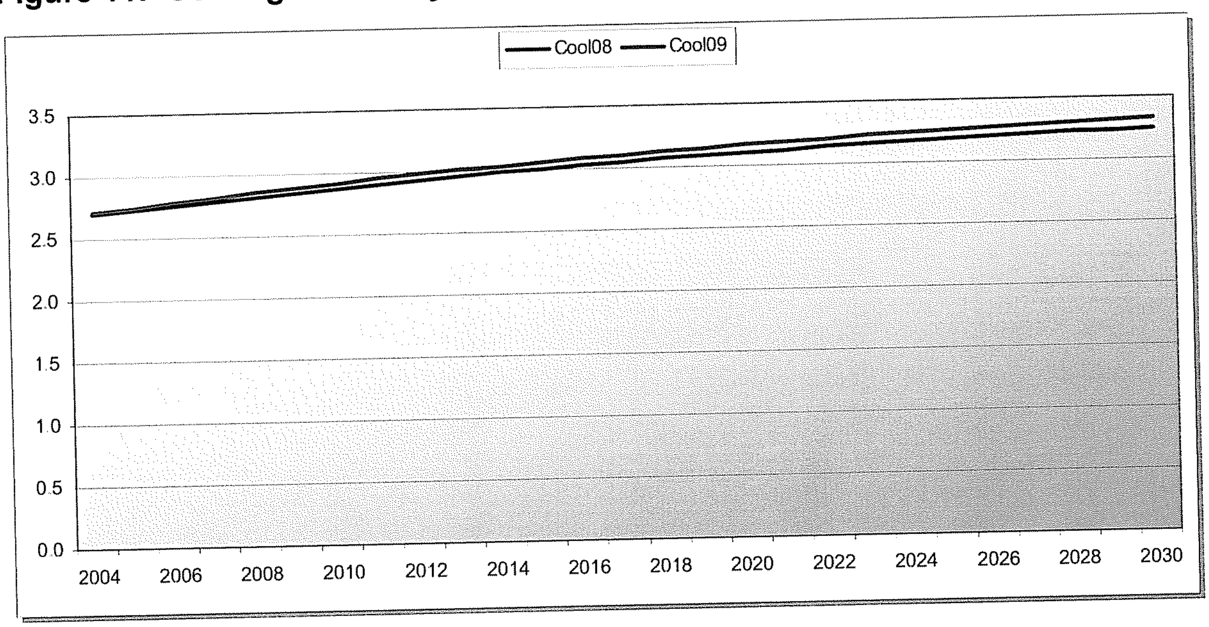


Figure 12: Water Heating Efficiency 2008 vs. 2009 (Btu output/Btu input)

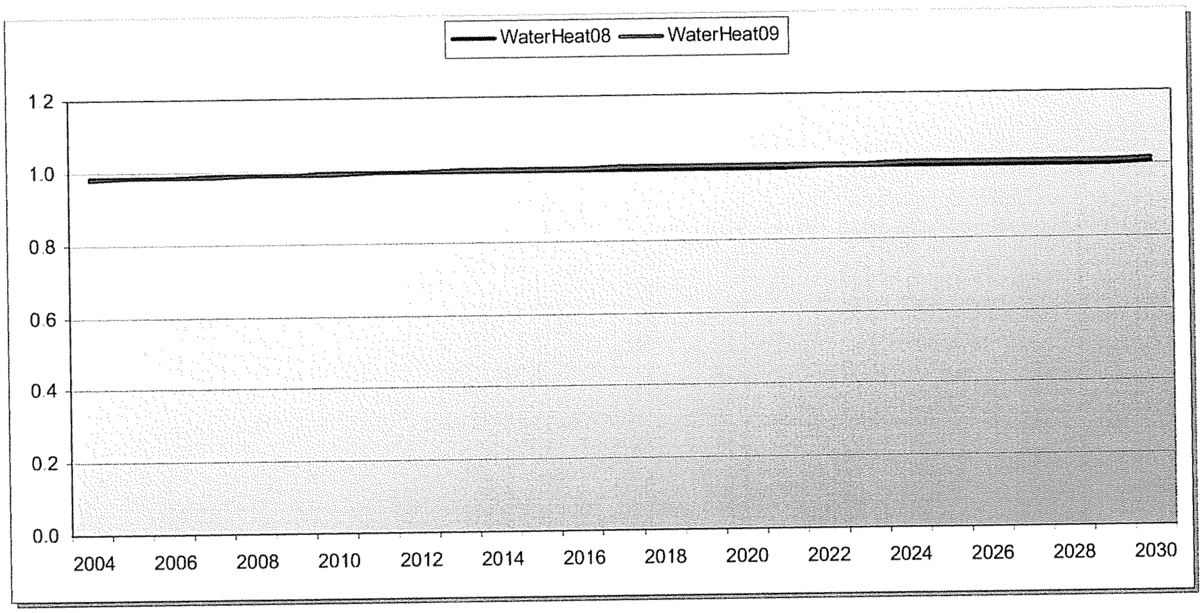
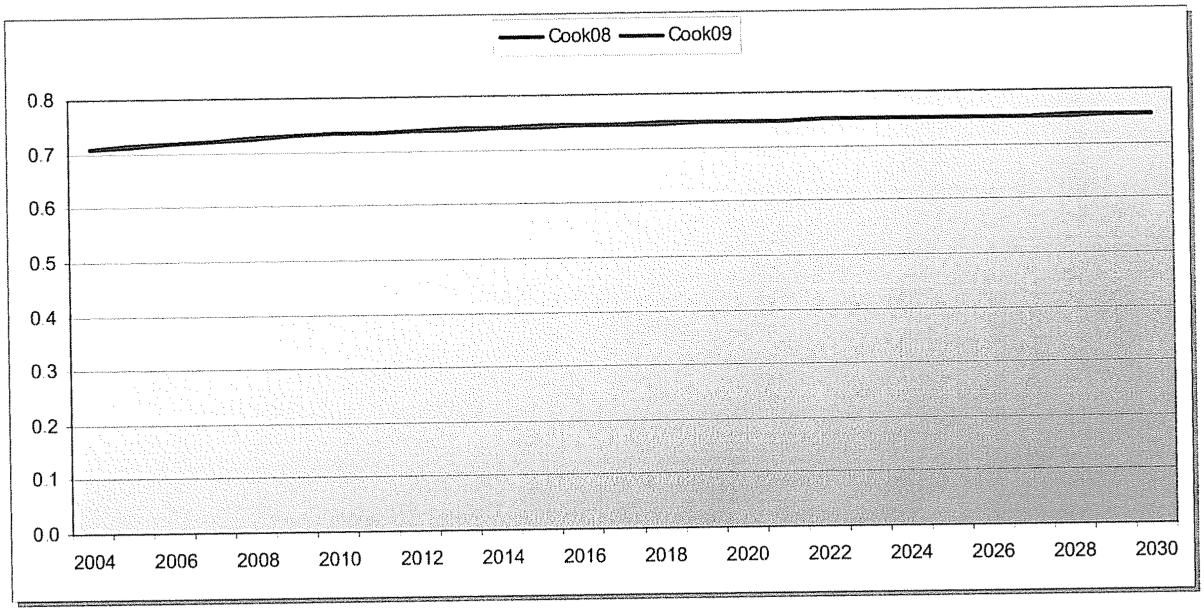


Figure 13: Cooking Efficiency 2008 vs. 2009 (Btu output/Btu input)



The most significant changes are in ventilation, refrigeration and lighting efficiency trends. Figure 14 through Figure 16 compare efficiency projections for these end-uses.

Figure 14: Ventilation Efficiency 2008 vs. 2009 (cubic feet per minute per Btu)

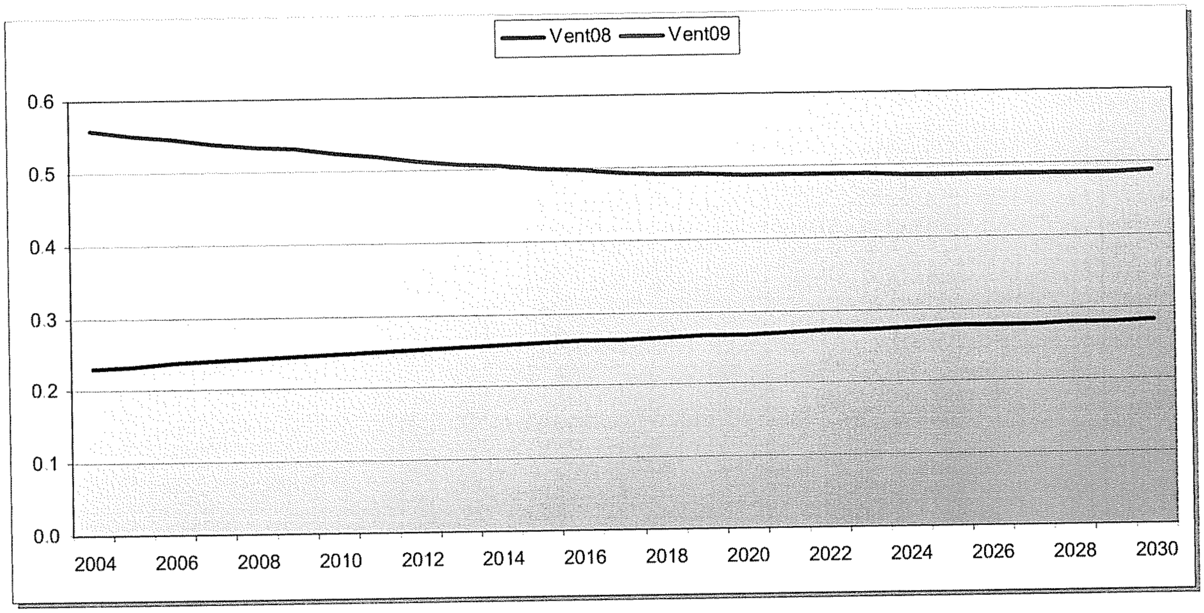


Figure 15: Refrigeration Efficiency 2008 vs. 2009 (Btu output/Btu input)

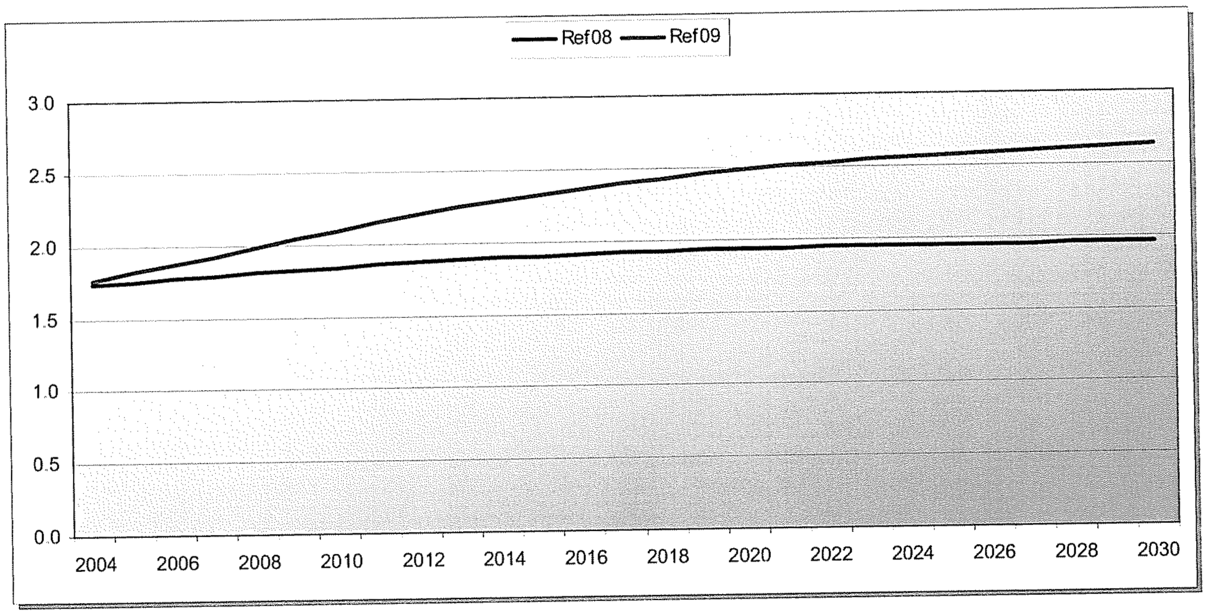
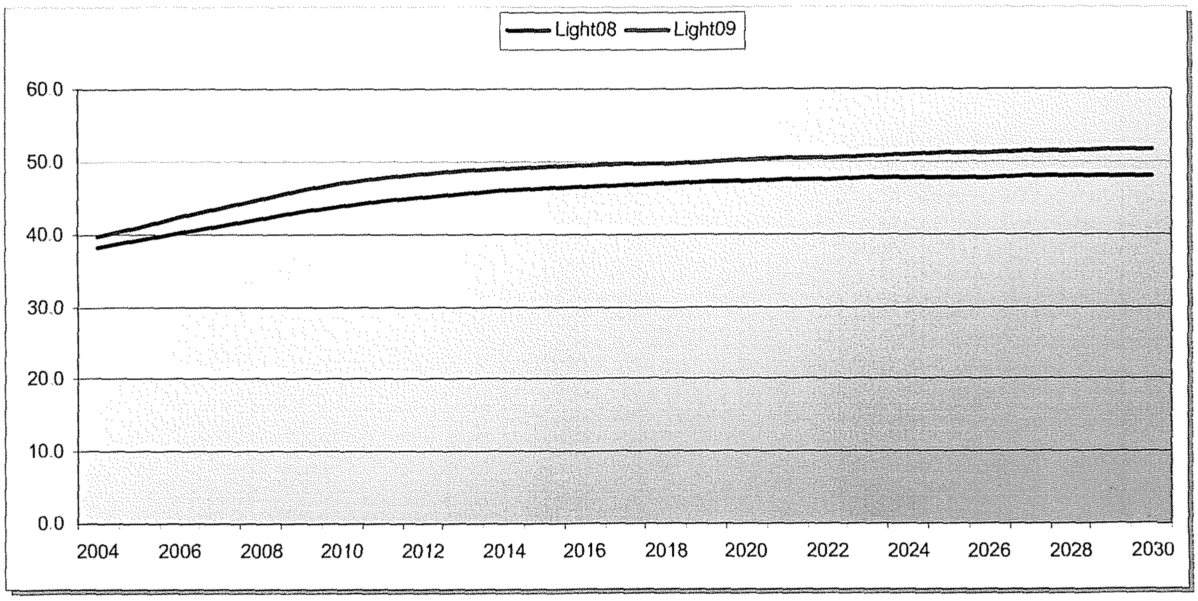


Figure 16: Lighting Efficiency 2008 vs. 2009 (lumens per watt)



1.3 End-Use Saturation Forecast Update

The SAE spreadsheets include a separate worksheet for end-use saturation projections; this allows the Analyst to modify end-use intensity projections that reflect end-use saturation unique to the utility service area. Unfortunately, the EIA does not provide end-use saturation forecasts. End-use saturation placeholders are calculated from the energy intensity and end-use efficiency projections. Saturation projections have been updated to reflect the 2009 intensity and efficiency projections.

To generate a saturation forecast, we assume that the end-use energy intensity (EI), over the long-term, is driven by changes in end-use stock ownership as reflected by the saturation rate (Sat) and changes in end-use efficiency (Eff). Given the EI and Eff forecast, we then estimate the saturation growth rate which is then applied to the starting base-year saturation estimates.

If we assume no change in the utilization of the stock over time, then we can attribute changes in the EI to changes in end-use efficiency (Eff) and saturation (Sat):

$$\%\Delta EI_{ct} = \%\Delta Sat_{ct} - \%\Delta Eff_{ct}$$

We calculate the annual percent change in EI and percent change in Eff from the estimated EI and efficiency projections. The percent change in saturation is then derived as:

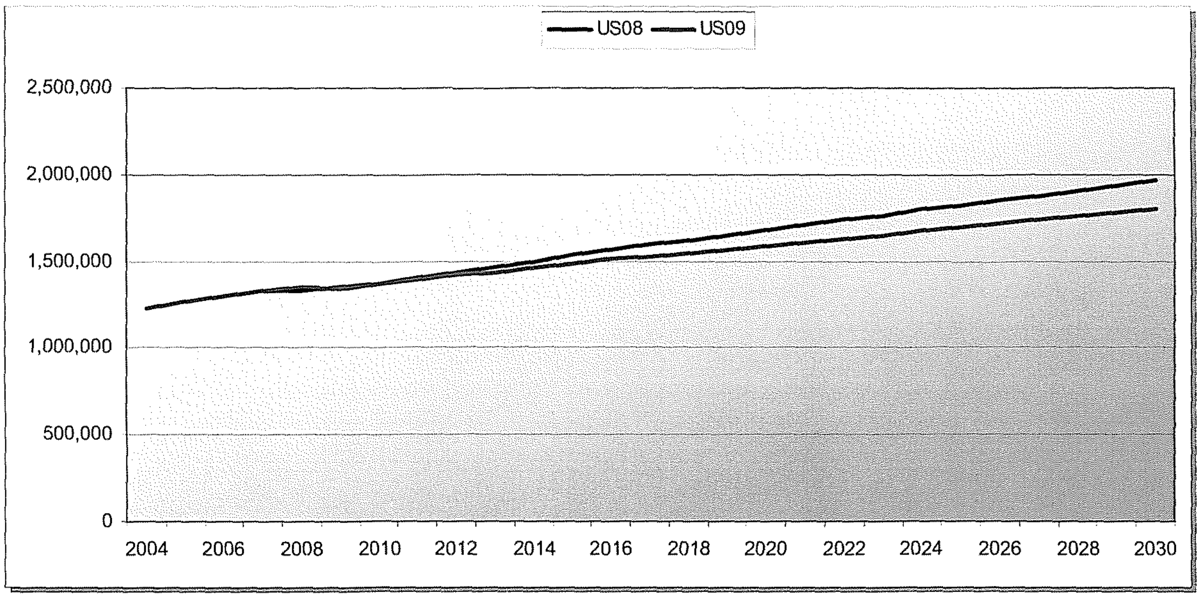
$$\%\Delta Sat_{ct} = \%\Delta EI_{ct} + \%\Delta Eff_{ct}$$

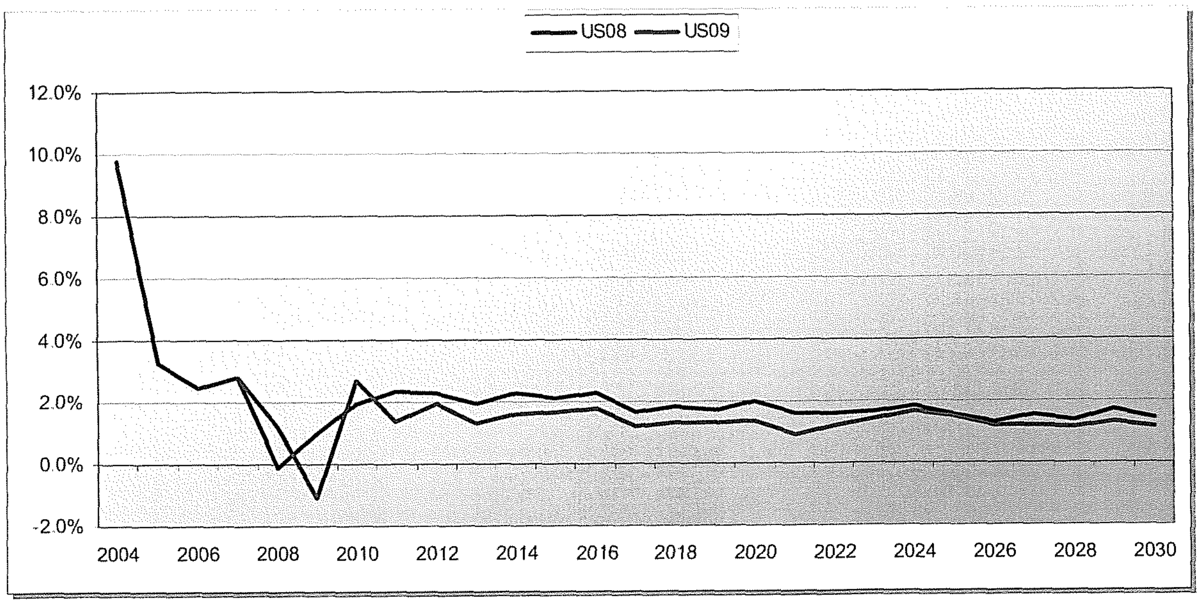
For example, if the heating EI is projected to decline 0.5% per year and the forecasted average heating efficiency is expected to increase 1.0% per year, the implied change in heating saturation is 0.5% per year: 0.5% = -0.5% +1.0%. Because there are other factors that contribute to the end-use consumption forecast (e.g., price, economic activity, and weather conditions), the EI tends to fluctuate from year-to-year. To mitigate this effect, we smooth through the EI series. The resulting saturation projection is only a rough estimate. The estimates are not designed to be accurate regional saturation forecasts but to act as a lever that allows the Analyst to modify end-use intensities to better represent the Analyst's service territory.

1.4 SAE Forecast Model Updates

SAE *MetrixND* forecast models are constructed for each Census Division. Models are linked to the Heating, Cooling, and Non-HVAC indices calculated in the SAE spreadsheets. Monthly SAE forecast drivers are built for heating, cooling and other use where the primary economic drivers are Census Division GDP and electric price projections. Models are estimated for total monthly electric consumption. The updated forecast reflects EIA's most current Census Division end-use intensity and price projections. Output projections are based on the fall 2008 GDP projection in both forecasts. The 2008 forecast is estimated with sales data through 2007 and the 2009 forecast is estimated with sales data through 2008. Figure 17 compares 2008 and 2009 U.S. commercial sales forecasts.

Figure 17: U.S. Commercial Sales Forecast (MWh) 2008 vs. 2009





Lower long-term end-use intensity projections coupled with higher real price projections translate into lower commercial sales growth. Commercial sales are projected to increase 1.6% annually (2009 to 2019) over the next ten years compared with last year's 2.1% forecast.

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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, the strength of econometric models is that they are well suited to identifying historical trends and to projecting these trends into the future. In contrast, the strength of the end-use modeling approach is the ability to identify the end-use factors that are driving energy use. By incorporating end-use structure into an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to this 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. This provides a strong bridge between the two forecasts.

- By explicitly introducing trends in equipment saturations and equipment efficiency levels, it is easier to explain changes in usage levels and changes in 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 document 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 2009 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

1.5 Commercial Statistically Adjusted End-Use Model Framework

The commercial statistically adjusted end-use model 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,

$$\text{USE}_{y,m} = \text{Heat}_{y,m} + \text{Cool}_{y,m} + \text{Other}_{y,m} \quad (1)$$

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.

$$\text{USE}_{m} = a + b_1 \times \text{XHeat}_{m} + b_2 \times \text{XCool}_{m} + b_3 \times \text{XOther}_{m} + \varepsilon_{m} \quad (2)$$

Here, $XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, 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 equipment saturation levels,
- Heating equipment operating efficiencies,
- Average number of days in the billing cycle for each month, and
- 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,

$$\text{XHeat}_{y,m} = \text{HeatIndex}_{y} \times \text{HeatUse}_{y,m} \quad (3)$$

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

The heating equipment index is composed of electric space heating equipment saturation levels normalized by operating efficiency levels. The index will change over time with changes in heating equipment saturations (*HeatShare*) and operating efficiencies (*Eff*). Formally, the equipment index is defined as:

$$HeatIndex_y = HeatSales_{04} \times \frac{\left(HeatShare_y \middle/ Eff_y \right)}{\left(HeatShare_{04} \middle/ Eff_{04} \right)} \tag{4}$$

In this expression, 2004 is used as a base year for normalizing the index. The ratio on the right is equal to 1.0 in 2004. In other years, it will be greater than one if equipment saturation levels are above their 2004 level. This will be counteracted by higher efficiency levels, which will drive the index downward. Base year space heating sales are defined as follows.

$$HeatSales_{04} = \left(\frac{kWh}{Sqft} \right)_{Heating} \times \left(\frac{CommercialSales_{04}}{\sum_e kWh \big/ Sqft_e} \right) \tag{5}$$

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 2004 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, prices and billing days. Using the COMMEND default elasticity parameters, the estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5} \right) \times \left(\frac{WgtHDD_{y,m}}{HDD_{04}} \right) \times \left(\frac{Output_y}{Output_{04}} \right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{04}} \right)^{-0.18} \tag{6}$$

where, *BDays* is the number of billing days in year (y) and month (m), these values are normalized by 30.5 which is the average number of billing days

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 2004, *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 one in the base year (2004). The first two terms, which involve billing days and heating degree days, serve to allocate annual values to months of the year. The remaining terms average to one 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 equipment saturation levels,
- Cooling equipment operating efficiencies,
- Average number of days in the billing cycle for each month, and
- Commercial output and energy price.

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

$$\text{XCool}_{y,m} = \text{CoolIndex}_{y} \times \text{CoolUse}_{y,m} \quad (7)$$

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:

$$CoolIndex_y = CoolSales_{04} \times \frac{\left(CoolShare_y / Eff_y \right)}{\left(CoolShare_{04} / Eff_{04} \right)} \quad (8)$$

Data values in 2004 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2004. In other years, it will be greater than one if equipment saturation levels are above their 2004 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.

$$CoolSales_{04} = \left(\frac{kWh}{Sqft}\right)_{Cooling} \times \left(\frac{CommercialSales_{04}}{\sum_e kWh/Sqft_e}\right) \tag{9}$$

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 2004 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:

$$CoolUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{WgtCDD_{y,m}}{CDD_{04}}\right) \times \left(\frac{Output_y}{Output_{04}}\right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{04}}\right)^{-0.18} \tag{10}$$

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 2004.

By construction, the *CoolUse* variable has an annual sum that is close to one in the base year (2004). 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 one 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 saturation levels,
- Equipment efficiency levels,
- 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:

$$OtherIndex_{y,m} = \sum_{Type} Weight_{04}^{Type} \times \left(\frac{Share_{y}^{Type} / Eff_{y}^{Type}}{Share_{04}^{Type} / Eff_{04}^{Type}} \right) \tag{12}$$

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.

$$Weight_{04}^{Type} = \left(\frac{kWh}{Sqft} \right)_{Type} \times \left(\frac{CommercialSales_{04}}{\sum_{e} kWh / Sqft_{e}} \right) \tag{13}$$

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

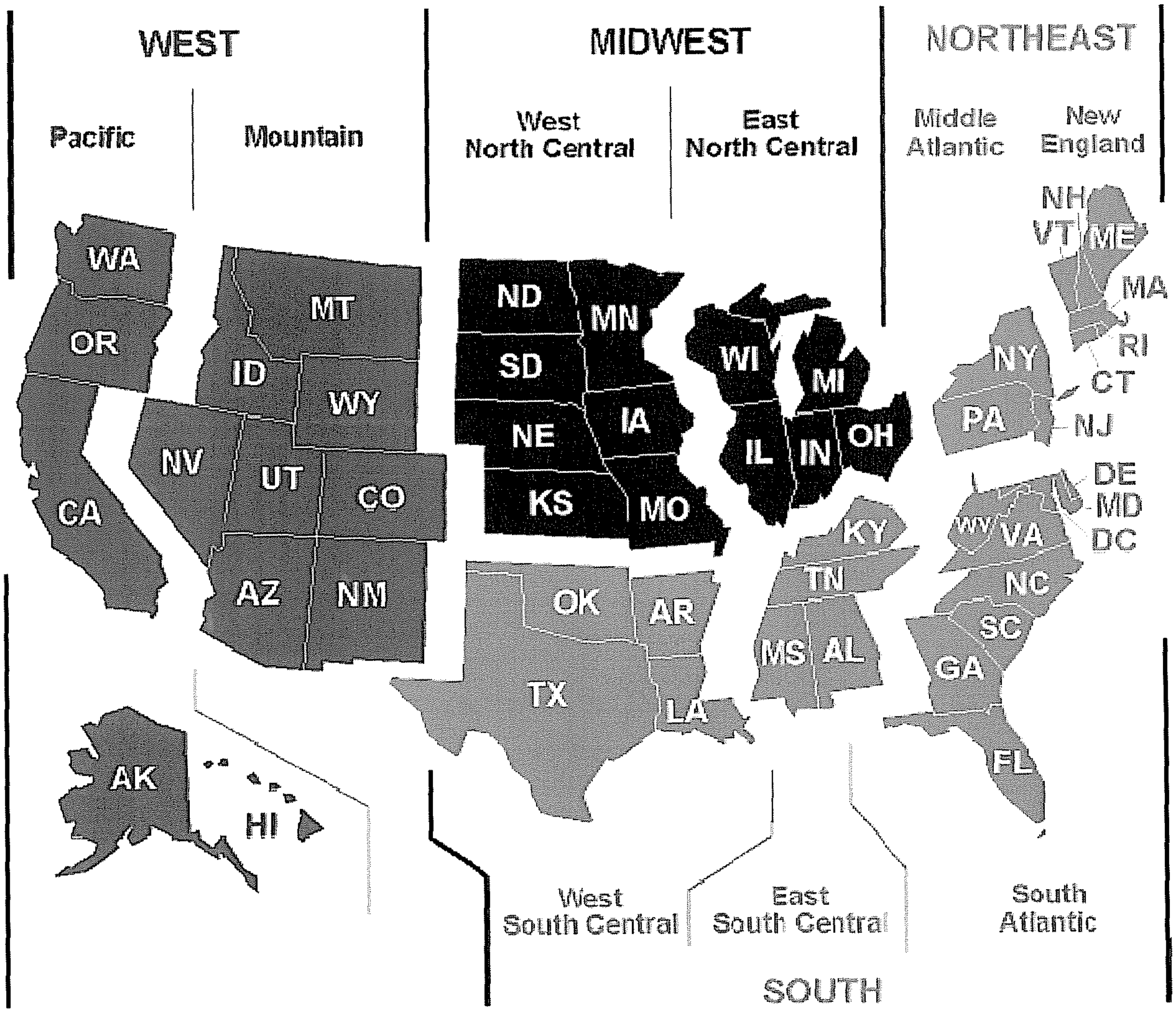
$$OtherUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5} \right) \times \left(\frac{Output_{y}}{Output_{04}} \right)^{0.20} \times \left(\frac{Price_{y,m}}{Price_{04}} \right)^{-0.18} \tag{14}$$

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

1.6 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*



*Map Source: URL: http://www.eia.doe.gov/emeu/reps/maps/us_census.html

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Table 1: List of SAE Files

Spreadsheets	*MetrixND* Project Files
NewEnglandCom.xls	NewEnglandCom.ndm
MiddleAtlanticCom.xls	MiddleAtlanticCom.ndm
EastNorthCentralCom.xls	EastNorthCentralCom.ndm
WestNorthCentralCom.xls	WestNorthCentralCom.ndm
SouthAtlanticCom.xls	SouthAltanticCom.ndm
EastSouthCentralCom.xls	EastSouthCentralCom.ndm
WestSouthCentralCom.xls	WestSouthCentralCom.ndm
MountainCom.xls	MountainCom.ndm
PacificCom.xls	PacificCom.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.

- **AnnualIndices**. This tab contains the annual Heat, Cool and Other equipment indices.
- **ShareEff.** This tab is used for the calculation of the annual equipment indices.
- **Efficiency.** This tab contains historical and forecasted end-use equipment efficiency trends. The forecasted values are based on projections provided by the EIA.
- **Shares.** This tab contains historical and forecasted end-use saturations. The procedure by which these are calculated is explained in the text above.
- **BaseYrInput.** This tab 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.

The *MetrixND* Project files are linked to the *UtilityData* and the *MonthlyEquipmentIndices* tabs in the spreadsheets. In this way, utility specific data and the equipment indices are brought into the project file. The *MetrixND* project files contain the following objects.

- **Parameter Table: Parameter.** This parameter table includes the values of the annual HDD and CDD in 2004 used to calculate the *Usage* variables for each end-use.

- **Parameter Table: Elas.** This parameter table includes the values of the elasticities used to calculate the *Usage* variables for each end-use.

- **Data Table: AnnualEquipmentIndices.** This data table is linked to the *AnnualIndices* tab in the Commercial SAE spreadsheet.

- **Data Table: UtilityData.** This link less data table contains census division data. It can be populated with utility-specific data.

- **Transformation Table: EconTrans.** This transformation table is used to compute the output and price indices used in the usage equations.

- **Transformation Table: WeatherTrans.** This transformation table is used to compute the HDD and CDD indices used in the usage equations.

- **Transformation Table: 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.

- **Transformation Table: BinaryVars.** This transformation table is used to compute the calendar binary variables that could be required in the regression model.

- **Transformation Table: AnnualFcst.** This transformation table is used to compute the annual historical and forecast sales and annual change in sales.

- **Model: ComModel:** This is the Statistically Adjusted End-Use Model.

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Question No. 2

Witness: Charles R. Schram

Q-2. Refer to pages 5-11 to 5-12 of the Resource Plan. Identify what provisions of the American Recovery and Reinvestment Act are incorporated into the Resource Plan, and explain how they were incorporated.

A-2. Please refer to Volume 2, pp. 213-227 for a description of the Itron Statistically Adjusted End-Use models that calculated the commercial and residential usage per customer energy. The models include the impacts for the EISA and ARRA.

More specifically, the Annual Energy Outlook 2009 (AEO2009) reference case was updated by the Energy Information Administration (EIA) to reflect the provisions of the American Recovery and Reinvestment Act (ARRA) that were enacted February 2009. SAE spreadsheets and end-use models have been updated to include new efficiency projections as a result of the ARRA.

The ARRA forecast builds on the end-use and building standards that were established with passage of the 2007 Energy Independence and Security Act of 2007 (EISA). Through the extension and expansion of various tax credits, and funding for state high efficiency appliance programs, ARRA results in adoption of more efficient end-uses and building shell thermal integrity measures (such as high efficient windows and home insulation) than in the 2009 reference case; this results in slightly higher average end-use efficiency projections than in the AEO2009 reference case forecast. See attached document titled "2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets-ARRA Stimulus Forecast" for more detail.

Attachment to Question No. 2
2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets-ARRA Stimulus Forecast
Witness: Schram

2009 Residential Statistically Adjusted End-use (SAE) Spreadsheets– ARRA Stimulus Forecast

The Annual Energy Outlook 2009 (AEO2009) reference case was updated by the Energy Information Administration (EIA) to reflect the provisions of the American Recovery and Reinvestment Act (ARRA) that were enacted February 2009. SAE spreadsheets and end-use models have been updated to include new efficiency projections as a result of the ARRA.

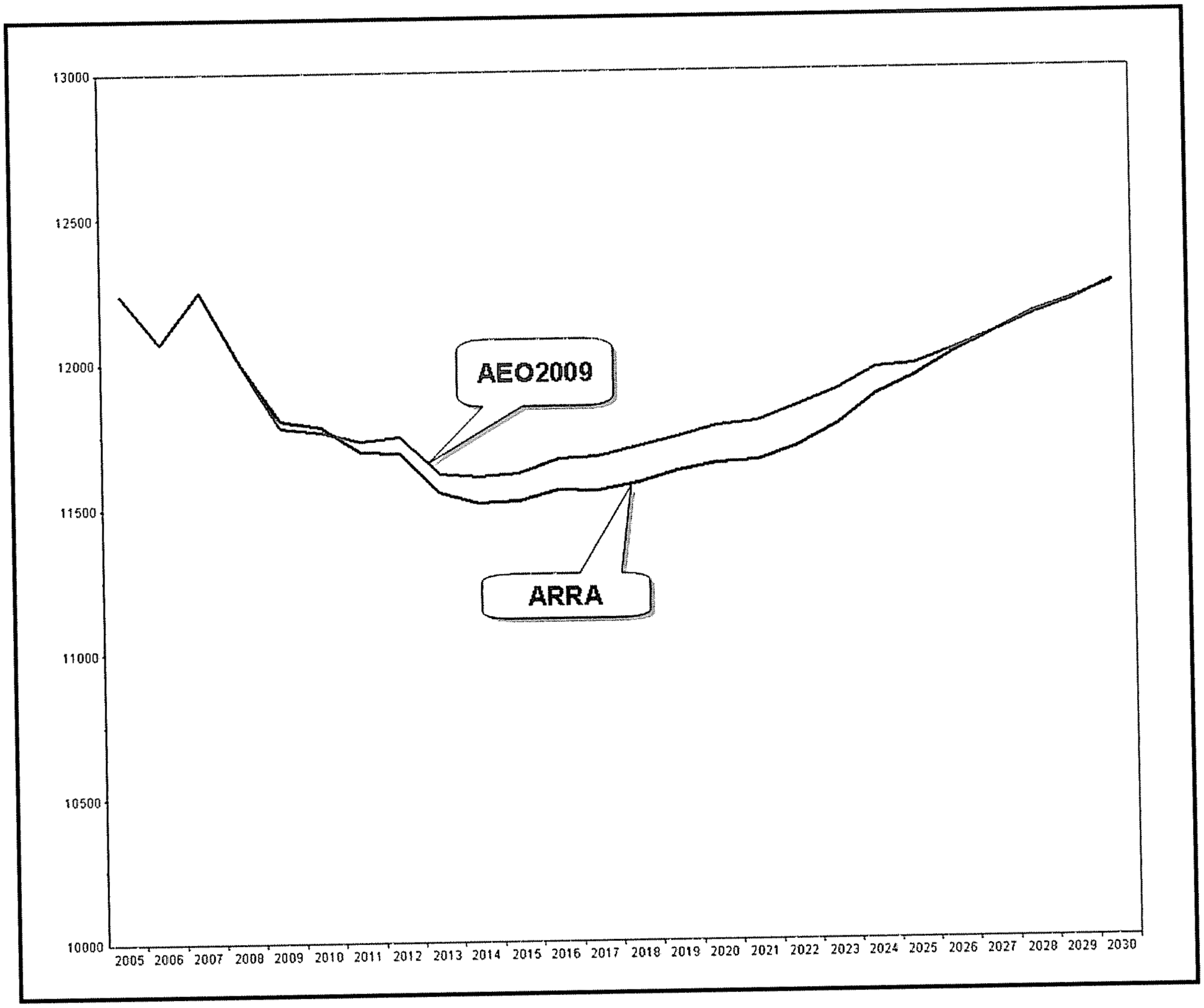
The ARRA forecast builds on the end-use and building standards that were established with passage of the 2007 Energy Independence and Security Act of 2007 (EISA). Through the extension and expansion of various tax credits, and funding for state high efficiency appliance programs, ARRA results in adoption of more efficient end-uses and building shell thermal integrity measures (such as high efficient windows and home insulation) than in the 2009 reference case; this results in slightly higher average end-use efficiency projections than in the AEO2009 reference case forecast.

Water heating is the one exception; water heating efficiency projections are slightly lower in the ARRA forecast. The ARRA extends credits for ground-source and solar powered water heating equipment, but ends tax credits for standard high efficiency water heaters in 2010. In the AEO2009 reference case, high efficiency water heater credits extend through 2016.

The ARRA reduces residential average use by roughly 0.2% annually over the next ten years. By 2020, ARRA efficiency programs reduce average use 130 kWh per household or 1.1% to 11,640 kWh per household.

Beyond 2020, average use actually increases slightly faster in the ARRA forecast. ARRA brings forward adoption of more efficient equipment sooner than what would have naturally occurred in the later years as reflected in the AEO2009 forecast. As a result average efficiency increases at a slower rate in the out years in the ARRA forecast when compared with the AEO reference case. By 2030, there is no difference between the ARRA and AEO reference case average use forecast. Figure 1 compares average use forecast for the two scenarios.

Figure 1: Residential Average Use Forecast Comparison (kWh)



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Question No. 3

Witness: Charles R. Schram

Q-3. Refer to page 5-12 of the Resource Plan. Identify which "previous government mandates" were incorporated into the Resource Plan, and explain how such mandates were incorporated.

A-3. Please refer to Volume 2, pp. 213-227 for a description of the Itron Statistically Adjusted End-Use models that calculated the commercial and residential usage per customer energy. The models include the impacts for the EISA and ARRA. The models also include impacts from previous government mandates, such as standards for appliance efficiencies in residential and commercial establishments. For example, general service lighting, Boilers, Dishwashers, and commercial walk-in refrigerators and freezers.

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Question No. 4

Witness: Charles R. Schram

Q-4. Refer to page 5-12 of the Resource Plan. Explain how "general increased awareness of energy efficiency ideas" was "incorporated" into the Resource Plan.

A-4. Please refer to Volume 2, pp. 213-227 for a description of the Itron Statistically Adjusted End-Use (SAE) models that calculated the commercial and residential usage per customer energy. The models include the impacts of general increased awareness of energy "efficiency trends" and ideas, p. 213 (commercial model) and pp. 223-227 (residential model) as end-use energy intensity and efficiency trends are captured through exogenous variables in the SAE framework.

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Question No. 5

Witness: Charles R. Schram

Q-5. Refer to page 5-49 of the Resource Plan. Identify what the "typical design life of a coalfired unit" is.

A-5. In this context, the typical design life of a coal unit is 50 years. According to the life assessment study provided in response to the Initial Requests for Production of Documents of Rick Clewett, et al., Question No. 3, Section B – Methodology (p. 3), it is "both reasonable and cost effective to retain properly operated and maintained units for a life of at least 60 years." As this study indicates, the actual life of a coal-fired unit is ultimately a function of the way the unit is operated and maintained.

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Question No. 6

Witness: Charles R. Schram

Q-6. Refer to page 5-50 of the Resource Plan. Identify what "additional investments" would be needed to "maintain continued operation" at the Companies' older electric generating units.

A-6. Please see response to Initial Request for Production of Documents of Rick Clewett, et al., Question No. 3.

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Question No. 7

Witness: Charles R. Schram / Counsel

Q-7. Refer to page 8-4 of the Resource Plan. For each of the Companies' coal-fired electric generating units, identify in which years over the life of the Resource Plan the Companies intend to carry out "three-to-four week boiler outages," and list each project the Companies plan to carry out during each outage, and the cost of each such project.

A-7. The quoted material referenced in the request for information is from a description of information in the Integrated Resource Plan. That material was provided only for informational purposes. The information requested was not used in the development of the Resource Plan in Integrated Resource Plan and therefore is irrelevant to the issues in this proceeding. Without waiver of this objection, Kentucky Utilities Company and Louisville Gas and Electric Company will file an additional response on August 4, 2011.

The maintenance plan incorporated in the Companies' 2011 Integrated Resource Plan is attached. The timing of three-to-four week outages is indicated in the attachment. The nature and cost of each outage project is not contemplated in the development of the Resource Plan. The timing of planned outages may change. Therefore, the IRP's analysis supporting the 2016 unit retirements was based on average maintenance cost assumptions that were escalated throughout the planning period.

The maintenance plan is confidential and is the subject of a Petition for Confidential Protection being filed herewith. The Companies will disclose the redacted confidential information to any intervenor with a legitimate interest in such information and as required by the Commission, but only after such an intervenor has entered into a mutually satisfactory confidentiality agreement with the Companies.

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Question No. 8

Witness: Charles R. Schram / Counsel

Q-8. Refer to page 8-4 of the Resource Plan. For each of the Companies' coal-fired electric generating units, identify in which years over the life of the Resource Plan the Companies intend to carry out the "target seven-to-eight year cycle for performing major maintenance." List each project the Companies plan to carry out during each such major maintenance, and the cost of each such project.

A-8. The quoted material referenced in the request for information is from a description of information in the Integrated Resource Plan. That material was provided only for informational purposes. The information requested was not used in the development of the Resource Plan in Integrated Resource Plan and therefore is irrelevant to the issues in this proceeding. Without waiver of this objection, Kentucky Utilities Company and Louisville Gas and Electric Company will file an additional response on August 4, 2011.

The maintenance plan incorporated in the Companies' 2011 Integrated Resource Plan is included as an attachment to Question No. 7. The timing of eight week outages (which occur on seven-to-eight year cycles) is indicated in the attachment. The nature and cost of each outage project is not contemplated in the development of the Resource Plan. The timing of planned outages may change. Therefore, the IRP's analysis supporting the 2016 unit retirements was based on average maintenance cost assumptions that were escalated throughout the planning period.

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Question No. 9

Witness: Counsel

Q-9. Refer to page 8-6 of the Resource Plan. For each of the Companies' coal-fired electric generating units, identify in which years during the life of the Resource Plan "boiler outages to replace boiler tube sections" have been scheduled.

A-9. The quoted material referenced in the request for information is from a description of information in the Integrated Resource Plan. That material was provided only for informational purposes. The information requested was not used in the development of the Resource Plan in Integrated Resource Plan and therefore is irrelevant to the issues in this proceeding.

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Question No. 10

Witness: Counsel

Q-10. Refer to page 8-7 of the Resource Plan. Identify which of the Companies' coal-fired electric generating units have replaced air heater baskets and in what year they did so.

A-10. The quoted material referenced in the request for information is from a description of information in the Integrated Resource Plan. That material was provided only for informational purposes. The information requested was not used in the development of the Resource Plan in Integrated Resource Plan and therefore is irrelevant to the issues in this proceeding.

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Question No. 11

Witness: Charles R. Schram

Q-11. Refer to page 8-18 of the Resource Plan. Identify any planned, anticipated, or assumed retirement dates for each of the Companies' electric generating units.

A-11. It was assumed in the 2011 IRP that Cane Run Units 4, 5, and 6, Green River Units 3 and 4, and Tyrone Unit 3 would all be retired effective January 1, 2016.

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Question No. 12

Witness: Michael E. Hornung

Q-12. Refer to page 8-87 of the Resource Plan. Identify the 80 DSM/EE programs that were assessed for inclusion in the 2008 Resource Plan, the 17 program enhancements and proposals that the Companies presented to their Energy Efficiency Advisory Group in September 2009, the 10 enhancements and programs that the Advisory Group found to be "useful, relevant, and a prudent use of consumer dollars," and the eight enhancements and new programs to be filed with the Commission in 2011.

A-12.

The 80 DSM/EE programs assessed for inclusion in the 2008 Resource Plan are:

Residential DSM/EE Programs Assessed for Inclusion in the 2008 Resource Plan

1	High Efficiency Heat Pump (replacing resistive heat)	23	Instantaneous Water Heating -Gas
2	Insulation	24	Strategic tree-planting
3	Window Shading and Films	25	Window Replacement
4	Duct Evaluation & Sealing	26	Removal of 2nd Freezer
5	Removal of 2nd Refrigerator	27	Replace Electric With Gas Clothes Drier Purchase Incentive
6	High Efficiency Outdoor Lighting	28	Dehumidifier
7	High Efficiency Heat Pump (replace existing unit)	29	Passive Solar Heating (new construction)
8	Occupancy Sensors	30	Air-to-Air Heat Exchangers (new construction)
9	High Efficiency Air Conditioning (replace existing)	31	Energy Star Clothes Washer Replacement Incentive
10	Energy Star Certification for Existing Homes	32	Freezer Replacement Incentive
11	Refrigerator Replacement Incentive	33	Water Heater Replacement (elect. to elect.)
12	Room Air Conditioner Replacement	34	Gas Air Conditioning
13	Water Heater Replacement (elect. to gas)	35	Electric Thermal Storage -Heating (special rate)
14	High Efficiency Heat Pump (replacing gas heat)	36	Daylighting
15	Responsive Pricing/Smart Metering/Energy Use Display	37	Door Replacement
16	Geothermal Heat Pump	38	Replace Electric With Gas Oven/Range Purchase Incentive
17	Solar Water Heating	39	Hydronic Distribution of Cooling and Heating
18	Electric Thermal Storage -Cooling (special rate)	40	Instantaneous Water Heating -Electric
19	Attic Ventilation	41	Photovoltaic
20	Dual Fuel Heating System	42	Solar Greenhouses and Sunspaces
21	Ceiling Fans	43	Windmills
22	Energy Star or Equivalent For Existing Multi Family Homes	44	Fuel Cells

Commercial DSM/EE Programs Assessed for Inclusion in the 2008 Resource Plan

1	High Efficiency Heat Pump (replacing resistive heat)	19	Daylighting
2	Window Shading and Films	20	Instantaneous Water Heating - Electric
3	Duct Evaluation & Sealing	21	Instantaneous Water Heating - Gas
4	High Efficiency Motors/ASD Motors	22	Strategic Tree Planting
5	Electric Thermal Storage - Cooling (special rate)	23	Cool Roofs (coatings, membranes)
6	Geothermal Heat Pump (new construction)	24	Water Heater Replacement (elect. to elect.)
7	Energy Management System	25	Solar Water Heating
8	Refrigeration Optimization	26	Water Heater Replacement (elect. to gas)
9	High Efficiency Heat Pump (replace existing unit)	27	Air-to-Air Heat Exchangers
10	Building Commissioning	28	Passive Solar Heating
11	Heat Pump Water Heaters - Restaurants & Laundrys	29	Hydronic Distribution of Cooling and Heating (small commercia
12	Refrigeration Case Covers	30	Door Replacement
13	High Efficiency Air Conditioning (replace existing)	31	Green Roofs (plants)
14	High Efficiency Cooking	32	Window Replacement
15	Clean CHP/CHRP	33	Photovoltaic
16	Desiccant Cooling	34	Windmills
17	Polarized Refrigerant Oxidant Agent	35	Fuel Cells
18	Chilled Water System Optimization	36	Solar Greenhouses and Sunspaces

The 17 program enhancements and proposals that the Companies presented to their Energy Efficiency Advisory Group in September 2009 are as follows:

17 Program Enhancements and Proposals Presented to the Energy Efficiency Advisory Group in September 2009

1	Home Performance with Energy Star	10	Residential Window/Door Replacement & Window Film Rebat
2	Behavioral Marketing	11	Commercial Customized Rebates
3	Energy Education Center	12	Commercial Refrigeration Rebates
4	Full Advanced Metering Infrastructure Deployment	13	Energy Star Manufactured Homes
5	Existing Demand Conservation Program Redesign	14	Commercial Cool Roof Rebates
6	Existing Demand Conservation Program FM Radio Solution	15	Geothermal Heat Pump Rebates
7	HVAC Rebates	16	Power Factor Correction
8	Residential Appliance Rebates	17	Solar Thermal and Photovoltaic
9	Refrigerator Removal Program		

The 10 enhancements and programs that the Advisory Group found to be "useful, relevant, and a prudent use of consumer dollars" are as follows:

10 Enhancements and Programs the Advisory Group found to be "useful, relevant, and a prudent use of consumer dollars"

1	Residential and Commercial Load Management / Demand Conservation Program	6	Smart Energy Profile Program
		7	Residential Incentives Program
2	Commercial Conservation / Commercial Incentive Program	8	Residential Refrigerator Removal Program
3	Residential Conservation / Home Energy Performance Program	9	Energy Education Center
4	Residential Low Income Weatherization Program (WeCare)	10	2011 Smart Meter Pilot / Network Automation Project
5	Program Development and Administration		

The eight enhancements and new programs that were filed with the Commission in 2011 are as follows:

The Eight Enhancements and New Programs to be Filed with the Commission in 2011

1	Residential and Commercial Load Management / Demand Conservation Program	6	Smart Energy Profile Program
		7	Residential Incentives Program
2	Commercial Conservation / Commercial Incentive Program	8	Residential Refrigerator Removal Program
3	Residential Conservation / Home Energy Performance Program		
4	Residential Low Income Weatherization Program (WeCare)		
5	Program Development and Administration		

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Question No. 13

Witness: Charles R. Schram

Q-13. Refer to page 8-92 of the Resource Plan. Explain the basis for the statement that "capital costs for both the coal and gas units have decreased by 20% and 10% respectively" since the 2008 Resource Plan, and identify any sources that you relied on in making that statement.

A-13. The changes in capital costs on page 8-92 of the Resource Plan were calculated incorrectly. The changes were computed by comparing escalated capital costs from the 2008 IRP to the capital costs used in the 2011 IRP. However, the capital costs from the 2008 IRP were escalated incorrectly. A summary of the corrected 2008 IRP capital costs as well as the updated percent change in capital costs from the 2008 IRP to the 2011 IRP is included in the table below. Compared to the 2008 IRP, the capital cost for a large supercritical coal unit in the 2011 IRP decreased by 7%, whereas the capital costs for 3x1 and 2x1 combined cycle units increased by 6% and 0.1%, respectively. The occurrence of this error is limited to the information on page 8-92. The capital costs used in the 2008 IRP were based on data provided in the Cummins and Barnard Generation Technology Options Study dated December 2007. The capital costs used in the 2011 IRP were based on data from the EPRI TAG and from the Combined Cycle Feasibility Study provided by HDR, Inc. In order to compare the different vintages of cost data, the 2008 IRP data were escalated from 2007 to 2010 dollars using an 8% escalation in construction costs. This escalation is the average of the Chained Price Index For Nonresidential Construction--Power And Communications and the Chained Price Index For Nonresidential Construction--Power Plants, updated by IHS Global Insight on October 7, 2010.

Construction Cost ($/kW)	**2008 IRP**		*2010 $*	
	2007 $	***2010 $***	**2011 IRP**	**% Change**
Large Supercritical Coal	2,498	2,698	2,520	-7%
3x1 Combined Cycle	756	817	869	+6%
2x1 Combined Cycle	879	950	951	+0.1%

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Question No. 14

Witness: Charles R. Schram

Q-14. Identify the energy generated (in KWh or MWh) at each of the Companies' electric generating units in each calendar year during the period 2000-2010.

A-14. Attached is the Annual Electric Energy by Unit for the period of 2000-2010.

Annual Electric Energy by Unit (2000-2010, Net MWh)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Brown 1	615,006	591,387	577,925	599,106	568,432	563,532	480,534	493,483	513,921	217,008	411,311
Brown 2	943,403	791,198	906,575	972,668	971,532	1,075,007	956,008	1,013,933	1,074,881	547,458	763,280
Brown 3	2,793,427	2,375,053	2,278,584	2,525,740	2,246,620	1,584,997	2,031,288	2,396,909	2,534,659	1,740,829	1,828,361
Brown 5	N/A	59,564	54,241	475	-1,161	122,928	30,777	19,823	2,340	2,380	8,061
Brown 6	20,557	3,351	102,829	15,696	10,767	172,114	97,500	88,563	21,817	36,780	48,131
Brown 7	24,229	48,009	84,941	14,034	20,684	156,711	99,276	51,599	33,143	26,632	46,851
Brown 8	44,764	38,203	34,815	4,782	-758	2,954	46,642	19,870	6,622	7,658	7,864
Brown 9	33,403	21,753	25,687	2,902	-14	1,636	27,105	11,236	3,411	1,509	5,196
Brown 10	25,401	13,605	18,418	3,579	772	1,683	20,966	5,334	1,722	2,370	4,365
Brown 11	16,340	8,079	10,471	406	636	1,854	13,070	4,458	677	4,551	8,529
Cane Run 4	923,971	882,739	966,836	971,150	813,652	1,052,063	961,053	1,105,274	1,044,031	950,924	927,129
Cane Run 5	940,250	1,008,640	1,078,881	1,038,855	897,296	1,091,048	1,087,296	1,043,893	886,232	956,126	1,110,383
Cane Run 6	1,350,265	1,408,314	1,022,287	1,544,055	1,514,046	1,542,731	1,530,907	1,395,319	1,482,371	1,340,828	1,222,086
Cane Run 11	373	339	122	38	33	143	1,179	312	4	210	228
Dix Dam	23,958	26,644	63,944	71,014	94,610	36,590	47,026	35,068	50,505	68,871	35,921
Ghent 1	3,153,430	3,661,109	3,223,170	3,448,042	3,304,417	3,488,619	3,374,404	2,915,043	3,598,899	2,867,588	3,295,876
Ghent 2	2,838,645	3,032,774	3,071,447	2,981,199	2,843,658	2,762,178	3,013,392	3,454,216	2,804,097	2,413,738	3,201,480
Ghent 3	3,210,133	2,918,140	3,093,384	2,265,509	2,829,972	3,086,506	2,967,905	2,358,308	3,262,152	3,182,388	3,431,840
Ghent 4	3,234,493	3,060,192	2,145,650	2,758,455	3,088,747	3,249,370	2,852,022	3,232,661	2,840,532	2,881,867	2,667,176
Green River 1	66,301	43,719	35,155	20,566	-885	N/A	N/A	N/A	N/A	N/A	N/A
Green River 2	57,626	34,917	29,574	18,825	-844	N/A	N/A	N/A	N/A	N/A	N/A
Green River 3	380,547	353,858	212,011	277,711	335,347	336,573	206,046	420,678	379,545	216,614	345,262
Green River 4	539,025	491,937	442,670	351,583	465,396	338,730	433,665	576,042	582,590	408,847	544,049
Haefling 1	358	-50	-136	-158	-144	-117	-130	-118	-115	-143	175
Haefling 2	234	-102	-124	-158	-146	-125	108	0	-123	-147	193
Haefling 3	205	-58	-130	-156	-149	-196	-101	-104	-129	-159	275
Lock 7	2	-13	-24	-13	-21	0	N/A	N/A	N/A	N/A	N/A
Mill Creek 1	1,769,257	1,822,807	1,785,523	1,970,334	1,847,144	2,223,638	1,975,638	2,163,431	1,994,139	2,121,020	2,009,037
Mill Creek 2	1,861,504	1,778,112	1,933,487	1,725,186	2,019,094	1,828,966	2,032,265	1,944,646	2,083,269	1,860,292	2,101,040
Mill Creek 3	2,506,522	2,722,661	2,386,458	2,706,297	2,297,199	2,969,840	2,842,591	2,805,103	3,002,860	2,805,833	2,914,876
Mill Creek 4	2,896,419	2,517,369	2,970,156	2,947,137	3,423,665	3,092,783	2,954,368	3,584,949	3,335,864	3,587,250	3,348,610
Ohio Falls	331,653	278,935	216,127	175,608	214,785	194,203	239,852	140,996	161,996	229,643	236,520
Paddy's Run 11	781	197	48	56	0	728	901	172	0	20	244
Paddy's Run 12	1,341	354	155	0	0	521	407	8	27	0	-107
Paddy's Run 13	N/A	48,923	108,288	30,235	31,448	134,487	89,512	66,288	6,552	1,262	14,729
Pineville	117,668	98,246	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Trimble County 1	2,586,805	2,519,945	2,863,345	2,771,658	3,114,522	2,886,772	3,160,653	2,708,402	3,058,244	2,346,678	2,672,799
Trimble County 5	N/A	N/A	103,154	36,252	20,896	8,925	11,776	92,508	73,993	43,447	129,014
Trimble County 6	N/A	N/A	98,777	29,154	22,887	22,459	23,796	83,953	69,784	28,245	100,290
Trimble County 7	N/A	N/A	N/A	N/A	30,982	44,210	50,944	112,701	59,477	39,370	125,685
Trimble County 8	N/A	N/A	N/A	N/A	21,578	77,153	76,814	149,775	63,039	33,229	98,268
Trimble County 9	N/A	N/A	N/A	N/A	25,172	46,514	59,506	148,371	58,192	29,733	125,067
Trimble County 10	N/A	N/A	N/A	N/A	13,204	90,645	71,377	130,929	51,431	21,367	103,884
Tyrone 1	-1,536	-1,312	-1,507	-1,503	-1,423	-1,404	-1,203	-192	N/A	N/A	N/A
Tyrone 2	-1,539	-1,600	-1,519	-1,513	-1,428	-1,408	-1,208	-193	N/A	N/A	N/A
Tyrone 3	297,630	266,999	254,389	264,143	238,273	355,762	253,848	390,188	355,632	23,524	137,167
Waterside	1,165	130	43	0	0	0	0	N/A	N/A	N/A	N/A
Zorn	777	237	53	43	0	0	403	263	0	231	93

Notes: *Figures are net of auxiliary load. Negative figures indicate auxiliary load in excess of gross generation.*
N/A is shown for units that were retired/sold or not yet in service.
Trimble County 1 data reflect LG&E's 75% ownership share of the generation.

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Question No. 15

Witness: Charles R. Schram

Q-15. Identify any of the Companies' electric generating units that have been designated as a must-run unit by MISO, PJM, or any other Regional Transmission Organization. For each such unit, identify when it was designated a must-run unit and the period of time for which the unit was designated as must-run.

A-15. The Companies are not members of a Regional Transmission Organization. Therefore, none of the Companies' electric generating units have been designated as a must-run unit by MISO, PJM, or any other Regional Transmission Organization.

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Question No. 16

Witness: Charles R. Schram

Q-16. Identify the Companies' actual electric energy sales in MWh and actual peak loads in MW for each of the years 2000 through 2010.

A-16. The table below contains the requested information for LG&E and KU. 2006-2010 was included in the IRP filing.

Year	Sales (MWh)	Peak (MW)
2000	30,145,000	6,317
2001	29,856,000	6,221
2002	31,347,384	6,513
2003	30,986,269	6,393
2004	31,895,295	6,223
2005	33,282,462	6,833
2006	33,550,211	6,863
2007	35,220,817	7,132
2008	34,188,953	6,357
2009	32,576,147	6,555
2010	35,237,777	7,175

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Question No. 17

Witness: Charles R. Schram

Q-17. Identify any CO2 prices assumed in the Resource Plan, and explain how any such CO2 prices were factored into the Resource Plan analysis.

A-17. No CO_2 prices were used in the preparation of the 2011 IRP. The Companies have not prepared or caused to be prepared a forecast or projection of possible future CO_2 costs, taxes, or emission allowance prices. The Companies have not done so because there is no reasonable basis on which to forecast such possible costs, all such costs being purely speculative at this time. Under its "Tailoring Rule", the EPA will regulate CO_2 emissions on a Best Available Control Technology ("BACT") basis. Current BACT solutions for fossil fueled generation, if triggered by permit actions, would not change the 2011 IRP. Carbon capture and sequestration technologies are not commercially viable on a large scale basis.

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Question No. 18

Witness: Charles R. Schram

Q-18. Identify all of the supply-side and the demand-side resources that you considered as part of this planning process.

A-18. For the supply-side resources, please refer to the IRP documentation in Volume III, Analysis of Supply-Side Technology Alternatives, Appendix A, Exhibit 1 – Technologies Analyzed in the Screening Process (p. 34). For the demand-side resources, please refer to the response to Question No. 12.

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Question No. 19

Witness: Charles R. Schram

Q-19. Identify the annual natural gas prices, coal prices, and power plant construction costs that you assumed as part of this planning process.

A-19. Please refer to the unredacted versions of the IRP provided in the response to the Request for the Production of Documents, Item No. 2. The coal and gas prices are identified in the IRP documentation in Volume III, 2011 Optimal Expansion Plan Analysis, Appendix A – System Data, Table 3 – LG&E and KU Fuel Costs (p. 22). The power plant construction costs are identified in the IRP documentation in Volume III, Analysis of Supply-Side Technology Alternatives, Appendix A, Exhibit 2(a) – Cost (Capital, Fixed and Variable Operation and Maintenance Cost), Heat Rate and Emission Rates Data (p. 36).

The Companies will disclose the redacted confidential information to any intervenor with a legitimate interest in such information and as required by the Commission, but only after such an intervenor has entered into a mutually satisfactory confidentiality agreement with the Companies.

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Question No. 20

Witness: Charles R. Schram

Q-20. Describe how the potential resource portfolios were developed as part of this planning process.

A-20. For a summary of the processes for developing the potential resource portfolios, please refer to the IRP documentation in Volume I, Section 8.5(a) (p. 8-89) and Section 8.5(c) (pp. 8-111 through 8-116). For a more detailed discussion of these processes, please refer to the IRP documentation in Volume III, Analysis of Supply-Side Technology Alternatives.

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Question No. 21

Witness: Charles R. Schram

Q-21. Identify all of the resource portfolios that you modeled as part of this planning process.

A-21. Please refer to the IRP documentation in Volume III, Analysis of Supply-Side Technology Alternatives, Table 6 – Technologies Suggested for Analysis within Strategist (p. 31).

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Question No. 22

Witness: Charles R. Schram

Q-22. Identify the assumptions you used in each base case and sensitivity scenario that you modeled in this planning process.

A-22. Please refer to the IRP documentation in Volume III, 2011 Optimal Expansion Plan Analysis, Appendix A – System Data (pp. 17-23).

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Question No. 23

Witness: Charles R. Schram

Q-23. Identify the net present value results of each modeling analysis that you performed as part of this planning process.

A-23. Please refer to the Response to the Commission Staff's First Information Request Dated May 26, 2011 (Case No. 2011-00140), Question No. 39.

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Question No. 24

Witness: Charles R. Schram

Q-24. Identify the discount rate you used in the modeling analyses that you performed as part of this planning process.

A-24. The discount rate of 6.71 percent is identified in the IRP documentation in Volume I, Section 9 – Financial Evaluation (p. 9-1).

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Question No. 25

Witness: Michael E. Hornung

Q-25. Identify the kW and kWh impacts to date from the Companies' energy efficiency and demand side management programs.

A-25. The current portfolio of DSM/EE programs through the end of 2010 has achieved a demand reduction of 182 MW and energy reduction of 207,900 MWh.

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Case No. 2011-00140

Question No. 26

Witness: Charles R. Schram

Q-26. For each of the Companies' coal-fired electric generating units, identify the anticipated annual capital, maintenance, and operating costs the Companies expect to incur during the time period covered by the Resource Plan.

A-26. The attachment contains the anticipated annual capital, maintenance, and operating costs used in the Resource Plan.

$000	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Capital															
Brown 1	2,783	15,418	19,395	11,196	799	815	831	848	865	882	900	918	936	955	974
Brown 2	1,436	4,559	15,707	15,968	16,153	2,684	1,375	1,402	1,430	1,459	1,488	1,518	1,548	1,579	1,611
Brown 3	3,041	3,102	5,294	30,289	43,708	16,650	3,425	3,493	3,563	3,634	3,707	3,781	3,857	3,934	4,012
Cane Run 4	826	842	859	876	894	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cane Run 5	895	913	931	950	969	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cane Run 6	1,279	1,304	1,331	1,357	1,384	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ghent 1	9,460	9,107	10,844	68,908	88,944	33,059	6,136	6,258	6,384	6,511	6,642	6,774	6,910	7,048	7,189
Ghent 2	21,781	85,610	117,077	126,669	82,204	29,440	6,252	6,377	6,505	6,635	6,767	6,903	7,041	7,182	7,325
Ghent 3	9,518	10,390	31,708	68,062	93,258	15,115	6,200	6,324	6,451	6,580	6,711	6,846	6,983	7,122	7,265
Ghent 4	9,506	10,009	21,738	63,773	83,522	13,727	6,187	6,311	6,437	6,566	6,697	6,831	6,968	7,107	7,250
Green River 3	417	426	434	443	452	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Green River 4	583	594	606	618	631	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mill Creek 1	3,293	12,890	50,587	91,220	14,245	8,822	4,248	3,783	3,859	3,936	4,015	4,095	4,177	4,260	4,346
Mill Creek 2	15,988	61,613	106,964	15,739	8,528	4,131	3,685	3,758	3,833	3,910	3,988	4,068	4,149	4,232	4,317
Mill Creek 3	4,250	8,990	47,519	120,571	90,175	4,692	4,786	4,882	4,980	5,079	5,181	5,284	5,390	5,498	5,608
Mill Creek 4	38,300	159,706	176,614	102,421	5,612	5,724	5,839	5,956	6,075	6,196	6,320	6,447	6,576	6,707	6,841
Trimble County 1	1,233	1,257	16,185	59,458	85,987	9,743	1,388	1,416	1,444	1,473	1,503	1,533	1,564	1,595	1,627
Trimble County 2	1,767	1,803	1,839	1,875	1,913	1,951	1,990	2,030	2,071	2,112	2,154	2,197	2,241	2,286	2,332
Tyrone 3	1,000	1,020	1,040	1,061	1,082	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
O&M															
Brown 1	4,307	5,315	4,381	7,294	8,188	8,797	9,098	9,348	9,700	9,874	9,980	10,396	10,688	10,895	11,225
Brown 2	7,152	7,100	7,385	10,782	13,299	16,220	16,747	17,232	17,819	18,214	18,704	19,237	19,512	20,050	20,604
Brown 3	17,803	26,078	20,611	28,574	26,160	37,803	37,544	38,382	43,462	45,278	46,837	47,765	49,226	49,999	51,652
Cane Run 4	16,384	9,729	12,645	13,758	14,066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cane Run 5	13,462	11,092	13,940	15,113	15,144	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cane Run 6	16,695	17,872	15,945	17,439	18,134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ghent 1	22,236	24,261	25,079	25,619	27,732	38,744	43,918	44,507	46,398	47,217	46,678	49,850	50,065	52,078	52,627
Ghent 2	14,277	21,886	17,471	24,084	24,730	36,779	39,908	40,961	40,748	42,879	43,416	44,590	45,170	46,413	46,995
Ghent 3	22,706	17,412	19,545	21,123	28,818	36,892	36,788	39,287	39,991	41,333	42,093	43,299	43,811	44,587	46,658
Ghent 4	18,150	20,338	21,803	23,989	31,527	43,446	46,926	47,356	49,282	50,103	51,622	50,882	53,713	54,484	56,167
Green River 3	5,410	7,223	5,205	5,401	5,559	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Green River 4	7,278	7,291	9,443	9,759	10,024	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mill Creek 1	13,510	19,945	14,269	34,127	40,363	44,191	45,638	46,400	47,718	48,145	49,782	50,464	51,797	52,534	53,889
Mill Creek 2	18,963	13,750	18,367	42,979	46,778	48,591	49,366	50,777	51,232	53,090	53,833	55,214	56,007	57,473	58,282
Mill Creek 3	25,701	21,739	25,708	27,563	52,923	59,078	59,743	61,813	61,373	64,698	65,183	67,274	67,820	70,094	70,636
Mill Creek 4	22,629	26,984	25,551	52,850	59,500	62,069	64,324	65,022	67,353	68,140	70,287	69,749	73,167	73,786	76,198
Trimble County 1	17,724	16,208	18,917	20,001	25,775	33,240	32,680	34,780	34,907	36,489	36,453	37,936	37,915	39,494	38,720
Trimble County 2	21,106	23,036	24,652	24,879	31,363	26,165	27,459	26,852	28,856	28,911	30,177	30,054	31,396	31,294	32,664
Tyrone 3	395	401	403	660	678	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes: *Trimble County 1 and 2 data reflect the Companies' 75% ownership share.*
N/A is shown for units that are assumed to be retired starting in 2016.

LOUISVILLE GAS AND ELECTRIC COMPANY
KENTUCKY UTILITIES COMPANY

Response to the Initial Interrogatories of
Rick Clewett, Drew Foley, Janet Overman, Gregg Wagner, the Natural Resource Defense Council, and the Sierra Club

Case No. 2011-00140

Question No. 27

Witness: Edwin R. Staton

Q-27. Identify any transmission grid upgrades or additions the Companies anticipate needing to make in order to avoid transmission grid reliability, stability, or voltage support problems as the result of the retirement of any of the Companies' existing electric generating units.

A-27. The transmission information provided in Volume 3 of this IRP filing contained infrastructure records that could expose a vulnerability through the disclosure of the location, configuration, or security of public utility critical systems. If such information is made available in the public record, individuals seeking to induce public harm will have critical information concerning the present vulnerabilities of the Companies transmission system. Knowledge of such vulnerabilities may allow such a person to cause public harm through the disruption of the electric transmission system. This information is considered confidential and may contain critical energy infrastructure information and was filed under Petition for Confidential Protection with the Commission.

Please see response Rick Clewett et al., Requests for Production of Documents Question No. 23.

LOUISVILLE GAS AND ELECTRIC COMPANY
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Case No. 2011-00140

Question No. 28

Witness: Charles R. Schram

Q-28. Identify any steps the Companies are planning to take or considering to address the impact that retirement of any of the Companies' existing electric generating units could have on the communities in which those units are located and/or the employees who work in those units.

A-28. In accordance with the KPSC's long-held precedent, the Companies did not evaluate externalities in determining the least-cost plan for meeting native load requirements and complying with anticipated environmental regulations.

LOUISVILLE GAS AND ELECTRIC COMPANY
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Case No. 2011-00140

Question No. 29

Witness: Charles R. Schram

Q-29. Refer to page 1 of the Companies' Analysis of Supply Side Technology Alternatives. Explain the basis for assuming that NOx and SO2 emission allowance prices will be zero starting in 2014. Identify any sources supporting such assumption.

A-29. When the 2011 IRP was developed, it was anticipated that CAIR would be phased out by 2014 and replaced with a program that would result in physical compliance and very limited interstate trading. The Companies assumed that the installation of additional NO_x and SO_2 controls would reduce its and other utilities' emissions below allocated levels, thereby eliminating the demand for NO_x and SO_2 allowances.