2023-2037

Load Forecast

Work Plan

Prepared by
Load Forecasting Department

December 2021

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Overview

The Rural Utilities Service ("RUS") requires East Kentucky Power Cooperative, Inc., ("EKPC") to maintain a load forecast approved by the EKPC Board of Directors ("Board") and RUS. The Code of Federal Regulations, Title 7 – Agriculture, Part 1710, Subpart E specifies the requirements for the load forecasts. EKPC has developed a Load Forecast Work Plan ("Plan") that details the scope, personnel and computer resources, data and software needed to develop the 2022 Load Forecast due to RUS December 2022. To ensure all of the RUS requirements are met, the Plan will be followed to produce the 15-year load forecasts for each of the 16 Owner-Members and develop the EKPC system load forecast.

The purpose of the *Load Forecast Work Plan* is to:

- Ensure EKPC and its Owner-Members comply with federal regulations related to load forecasts (7 CFR §1710 Subpart E).
- Provide a detailed scope of the methodology and processes to be followed in developing the load forecasts for the 2023 to 2037 planning period.

RUS approved the last such plan in December 2019 for use in 2020.

EKPC is electing the filing option specified in 7 CFR §1710.204(a) (2), therefore, the entire process described herein will repeat on a 2-year cycle. This ensures the Owner-Members and EKPC have up-to-date, approved load forecasts for their planning purposes. EKPC and the Owner-Members will use the resulting forecasts for long-term planning, including construction work plans, financial forecasts, transmission, generation, and demand-side management planning.

There is close collaboration between EKPC and its Owner-Members. EKPC will prepare a preliminary load forecast for each Owner-Member and meet with each to discuss the assumptions and the resulting forecast. Owner-Member personnel present at the meetings include the President/CEO and other key staff. Based on the discussions, revisions will be made, if needed. Owner-Members have access to information not available to EKPC or they may elect to use assumptions different from preliminary forecast assumptions. Input from Owner-Members includes industrial development, subdivision growth, and other specific service area information.

Consumers and energy will be modeled for each class reported on the RUS Form 7. EKPC's sales to Owner-Members are the sum of total retail sales and distribution losses. EKPC's total requirements are estimated by adding transmission losses to sales to members. Seasonal peak demands are based on appliance and class load shapes on a normal weather peak day.

Both parties have significant input into the load forecast process and both use the results for planning and decision making. The forecasts resulting from this partnership reflect a combination of a structured forecast methodology combined with judgment and experience of Owner-Member staff.

Timeline

- Winter 2021 / Spring 2022: The 2022 Residential End Use Survey will be conducted.
- Spring 2022: Other input data will be updated, and the models will be developed to produce a draft load forecast.
- Summer / Fall 2022: EKPC staff will develop a load forecast presentation that outlines the assumptions and the results to be presented during the visits with Owner-Members. Revisions will be made as needed.
- Fall / Winter 2022: The Management and Boards of Directors of the Owner-Members and EKPC will review and approve the final load forecast.
- December 2022: EKPC will submit the required documentation to the RUS Energy Forecasting Branch Chief for approval.
- Ongoing: EKPC staff will update the models periodically in order to identify any material changes that may warrant an update to the approved load forecast.
- December 2023: EKPC will submit an updated load forecast work plan to RUS.

Economic Forecasts by Owner-Member

A critical driver of the load forecasts is the regional economic outlook. EKPC has divided its Owner-Members' service area into seven economic regions based on service territorial boundaries and natural regions that exist within the EKPC territory. For example, the Central region fits closely within the Lexington Metropolitan Statistical Area ("MSA"). The Bureau of

Economic Analysis defines MSAs as areas of interrelated economic activity that go beyond a single county's boundaries. The Northern region includes Kentucky counties that border Cincinnati. The Southern region is influenced by tourism. The Louisville metropolitan area influences the West Central region. Finally, services and retail trade dominate the Northeastern region. Models for these regions provide EKPC with a way of linking the electricity needs of a service area to the rest of the economy in a consistent and reasonable manner.

IHS Global Insight ("IHS") is a firm that collects county-level historical data, models the data, and provides projections for key variables including: population, income, employment levels, wages, labor force, and unemployment rate. There are economists, assigned to Kentucky, who provide additional data or insights, as needed. Population forecasts are used to project residential class consumers. Regional household income is used to project residential energy sales. Regional economic activity is used to project small commercial energy sales.

Relating the regional data to the individual Owner-Member is a challenge due to the fact that service area boundaries do not correspond exactly to county boundaries used by IHS to produce the forecasts. To address this issue, EKPC uses the following method for each Owner-Member:

1. Aggregate the IHS Global Insight forecasts for the counties in a region. The most populous counties, such as Jefferson and Fayette, will be removed as these counties are served predominantly by investor-owned utilities. This will prevent these counties' economic conditions from unduly influencing the weighted aggregate economic indices.

2. Based upon analysis from the Residential End Use Survey, determine the appropriate portion of residential accounts that are actual residences versus those that are barns, seasonal buildings or other non-residence type accounts.

3. Create a weighted aggregate of the IHS Global Insight forecasts for the counties each Owner-Member serves using the share of the county's land area.

4. Calculate the ratio of population density of each Owner-Member relative to the population density of its weighted aggregate.

5. Forecast this relative population density ratio with a regression model using population density and time among the explanatory variables.

6. Apply the forecasted relative population density ratio to the weighted aggregate data to obtain adjusted economic indices.

Forecasts by Consumer Class

To comply with the requirements of 7 CFR §1710.205(b) (3), EKPC must forecast the number of consumers and energy usage by consumer class on an annual basis. The class forecasts are developed using a series of models and calculations within a statistically-adjusted end-use modeling framework.

Residential Class

Residential consumers are analyzed by means of regression analysis with resulting coefficients used to prepare consumer projections. Regressions for residential consumers are typically a function of regional economic and demographic variables. Different explanatory variables are used for Owner-Members in order to account for regional differences in local economies.

Two variables that are very significant for these regressions are the numbers of households by county in each economic region and the percent of total households served by the Owner-Member.

Model Inputs	**Source**
Population	IHS Global Insight database
Households - The number of households by county	IHS Global Insight database
Share – The percent of the region's households served by Owner-Member	RUS Form 7
Employment - Regional employment levels by SIC Code	IHS Global Insight database
Income – Regional income levels	IHS Global Insight database
Model Outputs	**Use of**
Residential Consumers	Residential consumers are input into the residential sales model.

Energy sales are forecasted using a statistically adjusted end-use ("SAE") model. This method of modeling incorporates end-use forecasts and can be used to separate the monthly and annual forecasts into end-use components. SAE models offer the structure of end-use models while also taking advantage of the strength of time-series analysis.

This method requires detailed information about appliance saturation, appliance use, appliance efficiencies, household characteristics, weather characteristics, and demographic and economic information. The SAE approach segments the average household use into end-use components as follows:

$$Use_{y,m} = Heat_{y,m} + Cool_{y,m} + Water\ Heat_{y,m} + Other_{y,m}$$

Where, y=year, m=month

Each component is defined in terms of its end-use structure. For example, the cool index may be defined as a function of appliance saturation, efficiency of the appliance, and usage of the appliance. Annual end-use indices and a usage variable are constructed and used to develop a variable to be used in least squares regression in the model. These variables are constructed for heating, cooling, water heating, and an 'Other' variable, which includes lighting and other miscellaneous usages.

$$CoolIndex_y = \sum_{Type} Wgt^{Type} * \frac{\left(CoolShare_y^{Type} / Eff_y^{Type} \right)}{\left(CoolShare_{98}^{Type} / Eff_{98}^{Type} \right)}$$

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{NormCDD} \right) * \left(\frac{HHSize_y}{HHSize_{by}} \right) * \left(\frac{Income_y}{Income_{by}} \right) * \left(\frac{Price_{y,m}}{Price_{by}} \right)^{-.30}$$

Where, by=base year

$$Cool_{y,m} = CoolIndex_y * CoolUse_{y,m}$$

The Cool, Heat, Water Heat, and Other variables are then used in a least squares regression which results in estimates for annual and monthly use per household.

Features of EKPC's SAE model are as follows:

- More than 20 years of Residential End Use Survey historical data are used to forecast saturation of appliances.

- Appliance efficiencies due to government regulation are accounted for using a standard roll-in method, where new households and existing households in the market for new appliances encounter more efficient units. Indices pertaining to appliance efficiency trends and usage are used to construct energy models based on heating, cooling, water heating and other energy for the residential class. Source: Energy Information Administration Annual Energy Outlook, East South Central region representing Kentucky.

- Forecasted demand response, distributed generation and energy efficiency impacts due to Owner-Member programs are accounted for using Owner-Member insight as well as planned budget funds. Additionally, rooftop solar and electric vehicle ownership are being closely monitored and forecasts incorporated.

- Various demographic and socioeconomic factors that affect appliance choice and appliance use are present in the methodology. These include the changing shares of urban and rural consumers relative to total consumers, number of people living in the household, as well as square footage of the house and the thermal integrity of the house.

Every two to three years since 1981, EKPC has surveyed the Owner-Members' residential consumers. The next survey will be conducted first quarter of 2022. Appliance ownership is analyzed in order to project future appliance saturations and to better understand electricity consumption.

Small Commercial Class

This class is analyzed by means of regression analysis, and the resulting coefficients are used to prepare sales and consumer forecasts. The sales regression consists of total small commercial sales as a function of price, weather, and some measure of the local or national economy. The consumer regression consists of small commercial consumers as a function of residential consumers, the unemployment rate, and time. Different explanatory variables are used for Owner-Members in order to account for regional differences in local area economies. For

example, small commercial sales in some territories are heavily influenced by the oil and gas industry, while other areas are more affected by retail stores.
This class is a challenge to forecast due to the relative heterogeneity of the consumers. Consumers in this class cover a wide range of electric use such as small mines, quarries, churches, schools, retail stores, large farm operations, and others. Additionally, this class has numerous reclassifications in the historical data which complicates the analysis.

Large Commercial / Industrial Sales Model

To forecast energy of existing customers information from Owner-Members with direct knowledge is used. Since there are so few large commercial and industrial consumers, use of regression to study the past history would reflect individual plant production or expansion decisions and not necessarily responses to economic conditions. EKPC and its Owner-Members have a two-part method for making projections in this class: existing consumer forecasts and forecasts of new consumers.

Forecasts of Existing Consumers: These projections are made directly by Owner-Members since they are in regular contact with the consumers. Each Owner-Member prepares a three-year projection of each consumer whose monthly demand exceeds 1 MW. Load forecasts beyond the three-year horizon for existing large commercial consumers are either fixed at the third year level or are adjusted based on information shared at the load forecast meeting.

Forecasts of New Consumers: In the short-term, two to three years, Owner-Members are informed by individual consumers of planned large load additions. Due to normal construction lead times, the ability to predict additions in the near term is strong. Beyond the three year horizon, regression is used to forecast new large commercial consumers. Because there are so few consumers in this class, analysis is initially done at the EKPC level to forecast total new consumers. These new consumers are then allocated to the Owner-Members using a probabilistic model which provides an analytical basis for allocating large loads on the EKPC system. The model distributes new large commercial consumers to Owner-Members based on their regional economic outlook, share of county served and historical growth.

Once the number of new large commercial consumers is determined, energy projections are based on the assumption that new large commercial consumers have the same characteristics as the average of existing large commercial consumers, a peak load of 1.8 MW with a 70 percent load factor. This methodology for forecasting new large commercial consumers and energy provides a defensible projection at the Owner-Member level.

Residential Seasonal, Public Street and Highway Lighting, Other Public Authorities Classes

Some Owner-Members report seasonal sales, street light sales and sales to public authorities as separate classes while others include these consumers in the residential or small commercial classes. EKPC's approach to modeling these classes is the same for each Owner-Member. Consumer and energy equations are developed using the related economic and member specific variables.

Forecasts of Own Use and Losses

For EKPC and each Owner-Member, future own use is assumed to be the average of recent historical own use, unless there is a planned renovation or expansion.

While there is no formal modeling process in loss analysis, Owner-Members provide input into the projected distribution loss assumption such as any right-of-way programs, which may reduce losses, and details concerning direct-served large commercial consumers, consumers with no distribution line. Using the average of recent years as a starting point, the Owner-Member will account for any planned upgrades for the projection. Transmission losses are projected similarly using recent history as a proxy.

Peak Model

EKPC's peak demand forecast is a bottom-up approach. The Owner-Members' peaks are summed to determine the EKPC peak. Model inputs include annual energy by end-use for the residential class and total energy use for small and large commercial. Model outputs are hourly demand for winter peak day and summer peak day. Weather sensitive appliance demands reflect typical peak day temperature profiles. The resulting peaks are explicitly linked to energy projections. Load factor is an input to the forecast. The load factors used are derived from data collected in the EKPC Load Research Program, historical data, as well as industry trends.

Scenario Analyses

Using the same tools and methodology previously described, scenarios are developed including:

- Pessimistic economics with mild weather
- Pessimistic economics with normal weather
- Base Case - Probable economics with normal weather
- Optimistic economics with normal weather
- Optimistic economics with extreme weather

Adjusting the following assumptions leads to different consumer forecasts which in turn results in different energy forecasts:

Weather: based on historical heating and cooling degree day data, alternate weather projections are developed based upon the 90^{th} and 10^{th} percentile to reflect extreme and mild weather, respectively.

Electric price: The general approach is to use price forecasts that are available and use the growth rates from those forecasts to prepare the high and low growth rates around the growth patterns for the base case residential price forecast. The manner in which the price of electricity will change in the future is primarily a function of how prices change for the underlying fixed and variable components of electricity rates.

Residential consumers: The basic approach to preparing high and low case scenarios for the future number of residential consumers is to determine the magnitude of variation in the past between long term average growth rates and higher or lower growth rates during shorter periods of time. First, the data on the historic monthly household counts for the previous 20 year period is prepared. Next, the compound annual growth rate in households is calculated for each rolling ten year. This produces a set of twelve compound annual growth rate values each representing a unique ten year span. Maximum and minimum values are determined. The highest growth is used to prepare the high case scenario, while the 10 year period that experienced the lowest growth is used to prepare the low case scenario.

These resulting adjustments are applied to the 20 year compound annual growth rate in the base case consumer count forecast to produce the high case and low case compound annual growth rate forecast scenarios. This relationship is preserved when preparing the monthly consumer counts for the high and low case scenarios.

Software

EKPC will use the following for data manipulation and modeling:

- Itron MetrixND will be used for regression analyses of consumers, energy and demand for each RUS class. MetrixND enables the use of a set of models, including linear regression and artificial neural networks, within a framework specifically built for load forecasting. The input datasets will reside in Microsoft Excel.
- Itron MetrixLT will be used to develop hourly data based upon the monthly forecasts from MetrixND and calibrated to historical hourly data.
- SAS, a statistical software package, will be used for data manipulation and analyses.
- Microsoft Office will be used for the creation of reports and presentations.

Data

EKPC maintains SAS and Excel datasets containing information from the following sources:

- EKPC Itron MV-90 database: hourly load data for each Owner-Member and wholesale rate
- EKPC EMS database: hourly EKPC system load data
- Residential Energy Use Survey data: a survey conducted every 2-3 years since 1981, designed to satisfy the requirements of 7 CFR §1710.209(g) by collecting data from a representative sample of residential consumers from each Owner-Member
- RUS Financial and Operating Report – Electric Distribution (formerly RUS Form 7): annual customer class-level and aggregate data by Owner-Member; monthly data provided by Owner-Members
- IHS Global Insight: observed and forecasted annual economic data for all counties in the state of Kentucky, as well as the aggregate
- Energy Information Administration (EIA):

- Annual Energy Outlook: observed and forecasted electricity usage by end use, consumer class, and Census Division, for a variety of economic and public policy scenarios, obtained via http://www.eia.gov/forecasts/aeo/
- Short-Term Energy Outlook: observed and forecasted monthly electricity usage by consumer class and Census Division, obtained http://www.eia.gov/forecasts/steo/
- Energy efficiency trends and projections

- NOAA National Climatic Data Center: climate normal for weather stations in or near the service areas of EKPC's Owner-Members
- DTN: observed and forecasted hourly weather for weather stations in or near the service areas of EKPC's Owner-Members.

Personnel

The load forecasting function is in EKPC's Load Forecasting Department in the Power Supply Business Unit. Key contributors include:

- David Crews is the Senior Vice President of Power Supply and will maintain executive authority and direction for the load forecast.

- Julia Tucker is the Director of Power Supply Planning, and will provide strategic oversight as well as management support of load forecast development.

- Jacob Watson, Senior Load Forecasting Analyst, will participate in the data development, modeling, and reporting of the forecasts.

- Mark Mefford, Senior Load Forecasting Analyst, will provide support for the load forecast process in areas of data collection, specifically, saturation survey data, load research data, and RUS Form 7 data.

- Scott Drake, Manager of Corporate Technical Services, will provide demand side management programs' impact on energy and peak demands for inclusion into the system forecast.

The Owner-Member personnel involved may include:

- President and Chief Executive Officer,
- Vice President of Finance,

- Vice President of Engineering and Operations, and
- Other key staff as selected by each Owner-Member.

RUS Required Deliverables

- A formal report documenting the systems results must include:
  - Executive Summary
  - Description of the Cooperative
  - Description of the Load Forecast Methodology and Assumptions
  - Regional Economic Model
  - Analyses and Results by Class
  - Scenarios
- Owner-Member Load Forecast Reports (CD)
- Board of Directors Resolutions (CD)
- Data, Models, Assumptions (CD)
- Hourly Results (CD).