MidwestISO
Energizing the Heartland

Peak Forecasting Methodology Review

Introduction

This document provides information intended to assist those developing annual forecasts of the peak demand of a Load Serving Entity [1] (LSE) coincident with Midwest ISO's summer coincident peak demand, for Midwest ISO's use in resource adequacy. There are many good texts and articles concerning peak forecasting, and the reader is encouraged to review the literature. Nonetheless, a concise review of the underlying principles and approaches that are appropriate for the annual, longer-term peak forecasting requirements facing LSEs within Midwest ISO seems warranted. At the outset, we wish to make clear that this document is intended primarily to assist, not prescribe, while at the same time delineating certain courses that are preferable and those that are unacceptable for the task at hand.

A definition of what is meant by "coincident peak demand" may be useful. Unless specifically indicated to the contrary, "coincident peak demand" shall be understood to be the peak demand of an LSE at the time of Midwest ISO's summer coincident peak, that is, Midwest ISO's largest peak when viewed as a single entity.

General Approach to Applied Research

Peak forecasting belongs to a larger class of studies known as applied research. The following outline briefly describes the major steps necessary in any professional applied research endeavor.

Review the Literature

The first step in any applied research is to obtain a good theoretical understanding of the topic under study. Reinventing the wheel should be avoided, if only on efficiency grounds. This necessary first step provides the analyst with a grasp of how the topic has been approached in the past, what the pitfalls and successes have been, and may suggest ideas for current or future analysis. Whether the analyst ultimately decides to follow an already well-developed method or to pursue a new approach, a good theoretical underpinning will prevent many mistakes and difficulties in later steps.

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[1] In retail choice states, the entity responsible for electricity distribution (EDC) is the entity that will develop the required peak forecast submissions for their entire distribution service area, including customers served by one or more LSEs within the overall service territory of the EDC. Future references in this paper to LSEs in this context should be understood to include these EDCs as well.
On a related note, one or more entities (e.g. municipalities or cooperatives), which provide electric distribution services but purchase some or all of their power requirements at wholesale, are considered "EDCs" for peak forecasting purposes. Such entities may transfer the obligation of providing peak forecasts to the distribution utility serving the surrounding area, supplying Midwest ISO with appropriate notice and documentation.

Develop the Theoretical Model

Developing the theoretical model includes several related steps. The two most important steps are the selection of the variables and the functional (mathematical) form of their inclusion.

First, the independent or explanatory variables must be selected, including how they should be measured. Theory should indicate a large number of factors that could plausibly be related to the variable under study. Selecting the important variables from theory is a large part of the art of modeling or forecasting. Omitting an important variable causes significant distortions to the results, while omitting an unimportant or minor factor results in few, if any, difficulties.

Second, the functional form (e.g. linear) of the variables must be chosen. Here, theory is often less of a guide, and more latitude is given to the analyst. However, the selection of any functional form carries with it certain assumptions or restrictions that the analyst must carefully weigh to ensure that reasonable results are obtained.

Collect, Inspect, and Clean the Data

This step may appear to be a simple exercise, but it often makes the difference between good results and bad. Data should be collected from reliable sources, well-documented and well-understood. Many empirical mistakes can be traced back to a lack of understanding regarding the actual dataset employed in the analysis. Inspecting and cleaning the data to ensure accuracy is a relatively thankless task, but should not be skipped or underrated. Using a large quantity of data in the hopes that this somehow acts to counter-act low quality data is a sure route to poor results.

Estimate and Evaluate Equation

This step includes the primary analysis of the data, typically utilizing ordinary least squares or other mathematical techniques suitable to the analytical approach selected. Results should be evaluated against both theory and common sense; there is no substitute for the analyst's ability to judge whether the results obtained are "reasonable".

Document Results

Long hours of literature review, careful model development, attention to the details of obtaining reliable data, and a skilled analytical effort can be rendered worthless if not appropriately documented. Copying statistical results from computer programs and providing reams of data are neither sufficient nor desirable documentation. The desired product includes a clear and concisely written document that outlines and summarizes the research effort in its entirety. Sufficient detail should be provided to allow the reader to understand the path followed by the analyst, the quantitative and qualitative results obtained, and any conclusions reached – all expressed in a comprehensible and transparent manner. Supporting data and statistical results should be available (e.g. in appendices) such that the reader could duplicate the results described.

Specific documentation requirements will be provided in the BPM. For a list of example documents, please see the section APPENDIX: FORECAST DOCUMENTATION EXAMPLE LIST.

Qualities of a Good Forecasting System

Having covered the general requirements of a well-performed applied research effort, we turn now to the narrower task of describing the characteristics desirable in a good forecasting system.

Much of the following was taken from a booklet prepared for the Edison Electric Institute by Charles River Associates, **A GUIDE TO ELECTRICITY FORECASTING METHODOLOGY**. While the publication is, from our current perspective, "old", its observations, comments, and conclusions remain valid.

A "good" peak forecasting system has certain general qualities that distinguish it from other systems. These qualities provide a useful basis for understanding why "good" forecasting systems outperform others over time.

Understandability

If users understand the rationale of a forecast, they can appraise the uncertainty of the forecast, and they will know when to revise the forecast in light of changing circumstances. *This characteristic is particularly important in planning.*

Credibility

The forecast will be reviewed by top management, the financial community, and regulators. The forecast should be credible to these audiences. Included under the label of "credibility", we would include *replication* (the same results should be achieved by another analyst following the same procedures) and *defensibility* (the forecast should withstand reasonable questions regarding its development and results).

Accuracy

The more accurate a forecast is, the better are the decisions that depend upon it. Inaccurate forecasts lead to too much or too little capacity and can be very costly. Note that accuracy can be separated into two distinct issues: first, how accurate is the forecast when the conditional inputs are accurate, and second, how accurate is the forecast given the conditional inputs used at the time the forecast was prepared and submitted? Answers to these questions will indicate whether additional work is required on the underlying model or on the process used to generate the conditional inputs.

Reasonable Cost

Forecasts cost money, time and effort. Added expense must purchase added accuracy, flexibility, or insight.

Maintainability

A sophisticated forecasting system requires ample staff resources and technical skills for maintenance. Choice of a forecasting system must include a commitment to the resources necessary to maintain it and avoid systems the utility will be unable or unwilling to maintain.

Adaptability

Forecasts are subject to change as a result of changing energy prices, the economy, and other factors. The forecasting system should be able to generate new forecasts in response to changing conditions. Forecasting models that can examine "what if" issues and evaluate hypothetical scenarios can help forecasters (and forecast users) respond to changing conditions.

Considerations in Forecast Development

Forecasting involves issues that the analyst must resolve if the forecast is to be effective. While the following list is not completely inclusive, it does illustrate the primary issues that require careful consideration.

Utilizing Available Data

Ideal data for forecasting are never fully available. Forecasting systems must be designed to rely on data that can be assembled at reasonable cost, in a reasonable time frame.

Acknowledging Uncertainty

Load forecasts are inherently uncertain. Forecast users need to understand the range of error. The analyst needs to present quantitative and qualitative measures of forecast uncertainty and to understand the sources of forecast error as they relate to key factors that influence electricity demand. The forecaster's understanding of the sources of uncertainty needs to be clearly conveyed to forecast users in a way that allows for their lack of familiarity with the forecast development process.

Reflecting Key Factors

Load growth reflects the influence of electricity prices, economic growth, population, and other key factors. Changes in these factors can lead to forecasting errors if not appropriately considered in the forecast modeling process.

Conditional Forecasts

Forecasts are "conditional" upon forecast model assumptions and projected values of key demand influencing factors. Conditional forecasting is important for examining the sources of uncertainty by relating forecasts explicitly to alternative values of key factors. It is also useful in examining historical experience. For example, a forecast based on normal weather may be inaccurate because of extreme weather but otherwise accurate.

Accommodating Change

Changing customer behavior, new uses, conservation programs, and other changes affect the accuracy of forecasts. Forecast must explicitly or implicitly allow for changes.

Preventing Double Counting

Forecasted reduction in energy use or peak loads from conservation or load management should not double count the impact of multiple programs or increased electricity prices.

Integrating Energy and Peak Forecasting

Consistency of energy sales, load shape, and peak load forecasts with one another must be reconciled with the accuracy of each forecast.

Selecting the Model for the Forecast Period

A forecasting system that produces accuracy for a 1-year forecast is not necessarily the best system for longer-term forecasting. The design of the forecasting system involves a choice of what forecast horizon is of primary interest.

Optimizing the Level of Aggregation

Disaggregating forecast models by end use, timing of loads, geography, or other factors can improve forecast accuracy or the usefulness of forecasts in planning, but it increases model complexity and makes models more difficult to maintain, understand, and explain to forecast users. The best forecasting systems concentrate detail where it is most useful for planning or improves accuracy.

Consistency

Forecasts of population, income, electricity rates and fuel prices, industrial production, and other key variables must be consistent with one another and with comparable assumptions used in utility planning. This consideration is acknowledged by requiring utilities to use the same forecast methods as those they use in their other regulatory planning submissions.

Forecasting Methodologies

There are many methods available to analysts when preparing a peak demand forecast. This section attempts to provide some guidance in distinguishing those methods that are acceptable to Midwest ISO in regards to forecasts submitted for resource adequacy purposes.

A word of caution or explanation is required to understand this section properly. Simply using an "acceptable" methodology will not guarantee blind acceptance of the peak forecast submitted. Within the broad class descriptions provided below, there exists the possibility of selecting an appropriate method but executing it poorly. For example, one can imagine an econometric model in which the coincident peak demand is forecast on the basis of sunspots. Such a model comes from an "acceptable" method (econometrics) and uses an "explanatory" variable (sunspots). Nevertheless, the model is unsuitable and would be rejected, as the proposed relationship is farcical. Another example would be a well-designed model that proposes to use an inappropriate input value in the calculation of the coincident peak. Midwest ISO will work with its members, particularly LSEs responsible for peak forecast preparation, through workshops, stakeholder presentations, and other forums in an effort to minimize potential misunderstandings regarding acceptability.

Acceptable List

The following list of forecast methods may not specifically include all potentially acceptable methods, but it does clearly indicate the basic approaches desired. To our knowledge, these methods are employed by all utilities within Midwest ISO's footprint for load forecasts submitted to regulators for planning purposes. If your particular forecasting method does not appear to fall within one of the categories listed, please contact Midwest ISO staff so that together we may review your approach to peak forecasting.

End-Use

End-use forecasts are based upon an enumeration of electricity-using activities ("end-uses") and specification of the level of use for each. While end-use forecasting is widely used by electric utilities, it has been criticized for several major shortcomings, including a tendency to under-forecast by missing new devices or activities and the use of engineering-based estimates that do not conform to actual consumer usage patterns or rates.

Econometric

Econometric forecasts are based upon statistically estimated forecasting equations linking electricity use to key variables such as electricity prices, fuel prices, customer income, commercial and industrial activity, weather, and major appliance stocks. Econometrics is also widely used by electric utilities. Criticisms of econometrics include its inability to directly account for certain specific programs, activities, or regulated requirements, either already in-place or forecast for the future. Econometrics is also used to estimate certain data used with end-use models.

Hybrid

A hybrid forecasting system employs an end-use structure embedded in an overall model with econometric estimation of some equations, particularly to estimate appliance usage, appliance stocks, and price impacts. Hybrid methods are also widely used by utilities.

Unacceptable List

The unifying trait of the methods found in the following "unacceptable" list is the lack of key factors that "explain" the forecast. Each of the following methods is essentially a "black box" that proposes to forecast peak demand primarily, if not exclusively, without direct reference to causal factors.[2] It is this lack of conditional methodology that sets them apart from the preceding list.

Time Trend

A time trend forecast is an extrapolation of historical trend. This method was widely used by utilities until its drawbacks became evident in the 1970s.

Time Series

A time series forecast, as that term is intended here, is also an extrapolation of historical trend using only data from the series to be forecast. Time series forecasting employs sophisticated

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[2] These forecasting methods, however, may be valid under other circumstances. Over longer horizons, causal explanation of the forecast becomes more critical.

statistical approaches in the examination of the past values of the series to be forecast. A time trend forecast can be viewed as an extremely simple time series forecast. The most recognized names in time series forecasting are Box and Jenkins, co-authors of widely used time series methods. Note that a time series approach may be appropriate for certain smaller load customer classifications for which explanatory analysis would be inefficiently expensive or time-consuming to determine. In addition, time series methods may be employed as part of an econometric approach to describe certain error patterns that remain even after the analyst has attempted alternative corrective approaches.

Informed Opinion

A forecast based on informed opinion is determined from expert judgment. This method is sometimes used to predict large industrial customer use, or new uses of electricity. The primary difficulties in using informed opinion are the lack of quantitative support, the inability to examine alternatives, and the qualifications of the "expert" making the forecast. Informed opinion should be used, in our judgment, to design a forecasting system that quantifies the "expert" knowledge in a way that allows for examination by outside parties.

Review Approach

Midwest ISO staff will review a sample of submitted forecasts each year. In that review, the **Considerations in Forecast Development** along with the following elements will be examined:

- Does the forecast approach follow appropriate theoretical guidelines?
- Does the forecast approach include appropriate causal variables?
- Is the overall "fit" of the equation(s) presented reasonable?
- Are the signs (±) on each coefficient in agreement with the underlying theory?
- What is the statistical confidence with which the coefficients are distinct from zero?
- Are coefficient elasticities or impacts in reasonable agreement with expectations?
- Are the input values used in the calculation of the peak consistent with the 50/50 approach?
- Do the equations suffer from any econometric issues, such as omitted variables, irrelevant variables, inappropriate functional form, multicollinearity, serial correlation, or heteroskedasticity?
- Are supporting studies relied upon for inputs relevant and up-to-date?
- Are intermediate results developed from sample data that is statistically reliable?

Given the variety of specific forecasting approaches and potential variations, it is not realistic to attempt an all-inclusive set of prescribed conditions that every forecast must meet in a programmatic, predetermined fashion. *The intent of the forecast review process is to determine whether the approach used and the results obtained are reasonably derived from causal factors employed, using a scientific and reproducible approach, and based on 50/50 conditions.* Forecasts prepared that meet these conditions will be approved.

There are three possible outcomes of the review process:

1. The forecast is acceptable,
2. The forecast would be acceptable given certain modifications, and
3. The forecast is unacceptable.

Forecasts falling in the first category will be approved in their present form. Forecasts falling in the second category will be returned to the forecasting entity with complete instructions for modifying the forecast such that it would be acceptable to Midwest ISO. Provided that the changes are made appropriately and submitted sufficiently prior to the forecast deadline for final review, the revised forecast will be approved. Forecasts in the second category which are not appropriately revised and forecasts in the third category will be rejected. In such cases, Midwest ISO staff will prepare the necessary forecast and the forecast entity will be billed the related charges for staff time incurred. Forecasting entities for which forecasts must be prepared by Midwest ISO will automatically have their forecasts reviewed in the following year.

General Approach to Coincident Peak Forecast

This section describes the desired general approach to determining the coincident peak forecast. Midwest ISO expects LSEs to begin the process by completing the forecast of non-coincident peaks and net energy for load in the manner suitable for their regulatory governing body. These typically well-developed and scrutinized forecasts will form the basis of the desired approach.

Starting from the most recently available non-coincident peak forecast prepared for retail regulators (RERRAs), the forecast of the coincidence factor should be developed. This development should focus on the relationship between the LSE's monthly non-coincident peak demands and the LSE's demand at the time of Midwest ISO's monthly peak. Historical data for the summer months (June – September) should be used, concentrating on data series (variables) that are likely to explain the coincidence relationship. The expectation is that weather will play the dominant role, although other factors may be important. Nevertheless, the precise way in which weather plays its role may differ among LSEs, based on geographic location, size, and other unique issues. The incorporation of local, detailed knowledge of customer usage patterns is precisely the sort of enhancement that is sought from this procedure.

Once the coincident relationship has been identified and estimated, the coincident peak forecast may be developed by inserting the "50/50" values required by the model described above. A concise and careful explanation of the derivation of these input values will be required in the submitted material.

While the approach outlined above is the expected course, entities responsible for providing the coincident peak forecast are free to discuss alternative approaches with Midwest ISO staff. The goal of coincident peak forecasting is to obtain accurate estimates of each entity's coincident peak – not to blindly follow a script that could be improved upon. At the same time, this open approach should not be construed as an invitation to follow a course that does not meet the standards of good forecasting, replicable studies, and the scientific approach generally.

Specific Approaches to Coincidence Factor Modeling

This section provides some broad comments on how the coincidence factor model might be constructed. As stated earlier, it is not our intention to provide any specific approach to the problem for several reasons. First, we believe that providing a specific approach would serve to depress, if not eliminate, independent thought and potentially innovative solutions. Each utility is unique, and each is free to discover a unique solution to coincident peak forecasting, within certain broadly framed constraints as already described. Second, we believe that each utility has access to specific local information and data that would be difficult, *a priori*, to specify or locate. For example, a utility may be aware of a large industrial customer that does not operate during certain relevant summer hours. Such a customer would contribute nothing to the summer coincident peak. Approaches applied to aggregate data would not, generally, incorporate these kinds of local knowledge.

Nevertheless, a few broad comments and observations regarding coincident peak forecasting and coincidence factors would seem warranted. Since we are assuming that a monthly non-coincident peak forecast [3] is available, our comments will focus on the transition to the annual coincident peak from those values.

The relationship between a coincident peak (CP) and a non-coincident peak (NCP) is known as a coincidence factor. In the usual case, where both the CP and the NCP come from the same time period (e.g. calendar month), the coincidence factor is constrained to lie between zero and one. The functional forms and modeling should carefully consider this restriction in development.

The factors that determine the CP would generally be expected to be those that determine the NCP, with a few exceptions. This is helpful, since to the extent that the causal variable values are unchanged between the CP and NCP, they need not be incorporated into the coincidence factor model. The primary exception would be weather, since expectations regarding the CP are likely to be different from that of the NCP. Another difference might be specific customer usage patterns. Other differences may exist, depending upon the modeling approach used to estimate the system's NCP values.

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[3] By "non-coincident peak forecast" we mean the peak demand of the LSE when considered as a single entity.

Special Issues

The following issues affect the forecast of coincident peak in some unique or unusual way that should be expressly considered and documented.

LMR: Demand Resources & Behind the Meter Generation

Load Modifying Resources (LMRs), comprised of demand resources and behind the meter generation, can be used to reduce demand, typically during peak conditions. Since both of these resources may receive specific planning credit for their contribution to meeting the planning reserve margin requirements, it is critical that the reductions (or contributions) are appropriately reflected in the modeling and reporting.

LMRs' reduction of the coincident peak should be separately determined, and then that amount should be added back to the actual coincident peak when determining historical peak values. The amount added back should include the appropriate "gross up" for losses, from the resource's measurement point to the normal measurement level of load for the LSE. For example, if the actual recorded coincident peak of the LSE is 100 MW, but during that hour LMRs were reducing the load by 5 MW (measured at the resources), and the loss factor from that measurement point to the LSE's measurement point is 7%, then the total historical coincident peak for the LSE should be 100 + 5/0.93 = 105.4 MW. Detailed calculations aside, the important point is to determine the load that would have been recorded by the LSE in the absence of the demand reduction.

Midwest ISO recognizes that there may be a difference between the expected contribution of an LMR (or all LMRs) towards reducing the expected coincident peak and (a) the amount of reduction actually experienced at any given historical coincident peak or (b) the amount of reduction historically or prospectively determined by the appropriate measurement and verification ("M&V") standards. Such differences may be largely attributable to weather conditions: for example, actual reductions will vary with actual weather, while forecasts are based on normal weather conditions.

Demand Response Resources (DRR)

Demand Response Resources should be treated in a manner analogous to LMRs described above.

Energy Efficiency (EE)

Registered Energy Efficiency should be treated in a manner analogous to LMRs described above. The proposed approach to resource adequacy would limit EE capacity credits to four years, following which such EE would become embedded in the unadjusted forecast.

Future Resources (LMR, DRR, EE)

Certain resources may not have existed at the time of the summer peak coincident with Midwest ISO's annual peak. The future estimated coincident peak demand of such resources should, of course, be included in the coincident peak demand forecast for the LSE, so that any future *reduction* may be appropriately credited towards meeting that coincident peak.

Registered (with the Midwest ISO) vs. Unregistered

An LSE may or may not register any given LMR or EE resource with Midwest ISO. Registered resources have already been discussed and their expected demand-without-reduction should be included in the coincident peak value. This is appropriate because the demand-without-reduction needs to be served, whether by demand reduction or through other resources.

For unregistered LMR or EE resource, a slightly different approach may be appropriate. First, in the development of the coincidence factors, any actual (achieved) load reductions should be treated in the same fashion already described for registered LMR reductions: added back to the load, so that the LSE's coincidence factor is developed on the basis of the total demand to be served. A "preliminary" forecast for the LSE would then be determined, representing the total demand to be met. At this point, the LSE could indicate reductions to the forecast for any demand reduction resource related amounts not registered with the Midwest ISO for planning purposes. These reductions would reflect the portion of its peak demand that the LSE believes will not need to be met by Midwest ISO planning resources. Any such reductions should, of course, be well-documented in the annual submissions provided by the LSEs. Moreover, such reductions would be expected to occur when the Midwest ISO has its peak, since capacity has been procured on that basis. Midwest ISO will monitor LSEs to ensure compliance.

Concluding Remarks

The approach proposed by Midwest ISO in the area of coincident peak forecasting is to begin, where possible, with load forecasts already routinely prepared for other regulatory and financial forums. By leveraging these forecasts, the additional expense related to coincident peak forecasts is minimized, and consistency with forecasts already used, reviewed, or widely disseminated is maintained. Only the final step, the conversion from a non-coincident peak forecast to a peak forecast coincident with Midwest ISO's footprint, is necessary.

In addition to minimizing the additional expense and effort required of its members, the proposed approach to coincident peak forecasting should reduce the expense incurred by Midwest ISO in its review process. Rather than requiring a complete review of the entire forecasting process, Midwest ISO can perform a much more limited review of the non-coincident peak development, and concentrate its efforts in the review of the final coincident peak step of the process.

Midwest ISO expects that this final conversion step, the development of a coincidence factor, will consist of determining the relationship between a utility's non-coincident (system) peak and the utility's peak at the time of Midwest ISO's peak. Given the nature of peak demand, this relationship will be primarily determined by differences related to weather conditions, and specific load characteristics of each utility.

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APPENDIX: FORECAST DOCUMENTATION EXAMPLE LIST

- Narrative summary of non-coincident peak forecast methodology
- Narrative summary of net energy for load forecast methodology
- Narrative explanation of coincident peak forecast methodology
- Description of equations including:
    - Variables (data series) used
        - Full names
        - Abbreviations used
        - Description of variable
        - Data source
        - Links to data used in development
    - Statistical output for estimations (as typically provided by software)
        - adjusted R^2
        - coefficient values
        - standard errors of coefficients
        - t-statistics of coefficients
        - standard error of regression
        - Durbin-Watson statistic
        - mean of dependent variable values used
        - standard deviation of dependent variable values used
        - time span of data employed in estimation
    - Graphical depiction of residuals
    - Tabular presentation of residuals
    - Graphical depiction of fitted and actual dependent variable values
    - Description of any adjustments made to data employed in equation
- Assessment of the reasonableness of the estimated coefficients, not from a statistical basis, but from an ‘economic common sense’ basis.
- Description of process used to determine forecast values used for independent (“explanatory”) variables
- Narrative description of any load-shape studies employed
    - Description of sample customers
        - Geographical location
        - Customer class / type
        - Sample selection criteria
    - Duration and time-period of sample data employed
    - Links to complete study reports
- Provision of supporting studies used to justify end-use parameters
- Provision of supporting materials used to benchmark end-use results
- Name, phone number, and e-mail address of contact individual knowledgeable of forecast preparation details
- One-page summary of coincidence factor employed or resulting from coincident peak forecast methodology, including high-level schematic of general approach used

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