

**To:** PJM Load Analysis Subcommittee  
**From:** Steve Wreschnig – PSE&G  
**Date:** November 16, 2010  
**CC:**  
**Subject: Proposed Itron PJM Load Forecasting Model Enhancements**

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## Introduction

During the last couple of weeks I've been asked by PSE&G to evaluate the PJM Load Forecasting model enhancements proposed by Itron. After reading the materials<sup>1</sup> and listening to the discussions in both Planning Committee Meetings and the most recent Load Analysis Subcommittee meeting, I have serious concerns about Itron's recommendations and the desire to quickly implement them. While I have raised my concerns at the LAS meeting, it is difficult for me to make a comprehensive and coherent statement of my position on this complicated subject "off the cuff" through a speaker phone. As a result, I feel that it would be productive for me to put my concerns in a document that, hopefully, will result in my concerns being better understood and, hopefully, make them easier to address.

I would appreciate it if you would read my comments and, if you agree with me, let me know. If you don't agree with me, please let me know what I've misunderstood or what I'm just plain wrong about and set me straight.

## Existing Models

Prior to looking at the Itron recommendations, I examined the information available from PJM on the current models. The estimated coefficients and precision of the estimates are available from PJM<sup>2</sup>.

The CP and NCP models are models of daily peak. They were estimated using data from January 1998 through August 2009. These models are used for both short-term and long term forecast out to 2025. These models have 55 independent variables and an intercept term. Of these 55 independent variables:

- Thirty-two are binary variables specifying time of the year (day, month, holidays, etc.).
- Nine are winter weather variables
- Eight are summer weather variables
- Three are Economic (GMP) or economic and weather interactive variables
- Others are "MinutesDaylight", "FuzzyHum", "DLSav EPA2005".

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<sup>1</sup> McMenamin, J. Stuart, Monforte, Frank A., Fox, Eric, and Sukenik, Andy, "Review of PJM Peak Forecasting Models, Phase I: Load forecast Model Evaluation, Phase II: Weather Modeling Methods", Itron Inc., 2010.

<sup>2</sup> PJM Load Analysis Subcommittee, "Load Model Statistics – 2010", December 2009.

### **Are the Current PJM Models Under-specified?**

Peak loads through time are influenced by a large number of economic, technological, and demographic factors that vary with time in the short- and long-term. Among them are:

- Changing energy prices
- Changing appliance saturations
- Changing customer mix.
- Demographic changes.

In the current PJM models, the only three of the fifty-three independent variables take into account non-cyclical and non-weather changes that can be expected to vary over time. These are the Gross Metropolitan Product (GMP), or the GMP interactive with weather variables. This seems inadequate in a model that is estimated over a period of ten years and used to forecast an additional fifteen years into the future given the trends that have been seen in the last decade.

I have additional concerns about this specification because of the inconsistency of the coefficient estimates across zones. For example, the GMP variable that is interactive with heating degree days (HDD) is positive for six zones. This implies that, all things being equal, if GMP increases, the impact of HDD on peak load increases. This intuitively makes sense. However, in thirteen of the zones the coefficient is negative implying the opposite. This doesn't make sense to me.

In addition, the AEP zone summer peak forecast "was adjusted downward by 600 MW to account for anticipated lingering impacts of the recession, judged by PJM staff not to be reflected in the forecast model."<sup>3</sup> Why would the impacts of the recession not be captured in the AEP model but, captured in the other eighteen zones. How was this adjustment determined? I find this rather troubling.

### **Are the Current PJM Models Over-specified?**

While the impact of large number of economic, technological, and demographic factors are basically ignored in the PJM specifications, the weather and day-type impacts are accounted for by 52 different variables. Thirty-two are binary variables specifying time of the year (day, month, holidays, etc.), nine are winter weather variables, eight are summer weather variables, and three others are "MinutesDaylight", "FuzzyHum", "DLSav EPA2005".

My initial reaction to this is that there are too many variables – along the lines of the "over-trained" neural networking model. I'm also at a loss as to why "Minutes of Daylight" should be in a daily peak model. I also wonder why, with 17 different winter and summer weather variables, an additional stand-alone humidity variable is required.

It's also troubling that the impact of these very specific variables does not vary over time. For example, the day after Thanksgiving is assumed to have the identical impact in 2009 (or 2015 for that matter) as in 1998.

While it is difficult for me to evaluate the reasonableness of this specification, my thought is that, if this is a valid specification, there should at least be somewhat consistent results across zones. If there are inconsistent results, they should be explainable. In examining the model results by variable a couple of things jump out:

- All things being equal, December is the highest peak month for seven of the zones, January for nine of the zones, and February for three of the zones.

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<sup>3</sup> PJM – Resource Adequacy Planning Department, PJM Load Forecast Report – January 2010, page 1.

- All things being equal, Sunday is the lowest peak day for thirteen of the zones. Saturday is the lowest for the other six.
- Morning HDD have a positive impact on peak in nine zones, a negative impact in ten .
- Afternoon HDD have a positive impact on peak in seventeen zones, a negative impact in two.
- Night CDD and morning CDD have negative impacts on peak in sixteen zones but a positive impact in three zones (not the same zones, however).
- Weekend HDD have a positive impact in thirteen zones, a negative impact in six.
- The coefficient on the “ColdWind” variable is positive in nine zones and negative in ten.

I don't find these inconsistencies reassuring. I would assume that PJM examined these inconsistencies and have explanations. If not, I would be very concerned that some of these independent variables have statistical significance due to spurious correlation and should not be included in the specification.

**My Recommendation:** My conclusion from looking at the PJM models is that there is insufficient control in the specification for the changing economic, technological, and demographic factors that impact not only the peak loads but, also the response of the peak loads to all of the day-type/holiday binary variables necessary to estimate the model over a decade of historical data and to use the model to forecast ten years out. This, of course, probably isn't a great revelation to anyone.

Itron was commissioned to evaluate the existing models. Itron has made seven recommendations and five will be discussed in the sections below.

## Itron Recommendations

### Recommendation 1: Implement Index 1 as the Economic Activity Variable.

The purpose of Recommendation 1 is to substitute an aggregate index of economic activity to take into account drivers such as population, households, personal income, etc. that are not incorporated into the current specification. While the incorporation of additional economic/demographic variables is a necessary enhancement to the models, I am not comfortable with how it is proposed to be implemented.

My understanding is that the industry was surveyed to find out what drivers were used in the various load models and what relative importance was attached to each. The average weights from the survey were used to construct Index 1. In general, Index 1 can be written as<sup>4</sup>:

$$\text{Index } 1_{y,m} = \frac{(\text{HH}_{y,m}/\text{HH}_{\text{base}})^{0.28}}{(\text{GDP}_{y,m}/\text{GDP}_{\text{base}})^{0.17}} \times \frac{(\text{Pop}_{y,m}/\text{Pop}_{\text{base}})^{0.11}}{(\text{GMP}_{y,m}/\text{GMP}_{\text{base}})^{0.15}} \times \frac{(\text{NMEmp}_{y,m}/\text{NMEmp}_{\text{base}})^{0.15}}{(\text{PInc}_{y,m}/\text{PInc}_{\text{base}})^{0.14}} \times$$

Where:

HH = Number of households,  
 Pop = Population,  
 NMEMP = Non-manufacturing employment,

<sup>4</sup> Itron, Inc. Forecasting and Load Research Solutions, “Review of PJM Models Phase I: Load Forecast Model Evaluation”, page 28.

GDP	= U.S. Gross Domestic Product,
GMP	= Gross Metropolitan Product,
PInc	= Regional Personal Income.

There are a couple of things about Index 1 that just don't make sense to me.

Including the number of households (HH) makes sense to capture the impact of the changing residential sector on peak. If you have households, however, why do you need population (Pop)? Itron claims that growth in population is a driver of residential use per customer but, that makes no sense to me.<sup>5</sup> I've used Pop as a driver for the demand for commercial services but, if that's the case here, why do you need NMEmp? Personal income is another driver for the demand for commercial services but, it has population as a component which is already included in the index. If you want to include both demographic and income drivers for commercial activity, you're better off using per capita income, not total.

If the Gross Metropolitan Product is included as a measure of economic activity, why do you need GDP? GDP has been used as an estimate of the trends in local output if no local measure is available but, if you have GMP, there's no reason to include GDP.

It appears to me, that survey respondents each used a subset of the possible economic/demographic explanatory variables. However, it's possible that none used them all. If a respondent used GDP, GMP wouldn't be used and vice versa. This index appears to be an aggregation of variables that in a single model are redundant. The specification of the variables in this index doesn't make sense to me.

In addition, aggregating these variables into an index prevents any meaningful testing as to the reasonableness of the components that are included. Itron states that the aggregation into an index avoids multi-collinearity issues<sup>6</sup>. That is true. You are avoiding the multi-collinearity issue but, you're not solving it. There is still not a precise empirical estimate of what each component is contributing to the model estimation process. A possible imprecise empirical measure is just replaced with Itron's ad hoc weighting system. I don't see that as a solution.

In addition, the weighting system itself is constant across all the zones. This is not reasonable given the diversity of the PJM footprint and, as a result, also does not make sense.

**My Recommendation:** It would make more sense to me to follow the standard economic empirical process. Determine from the broad base of industry knowledge what the appropriate economic, demographic, and technological independent variables that should be included in the load models and estimate statistically what the impacts on load are for each zone.

## **Recommendation 2: Include Price Shift variables in the CP and NCP Models**

It is generally accepted that the price of electricity has an impact on peak loads. Furthermore, if price is not accounted for in the model specification, other model estimated coefficients can be biased depending upon the correlation of the other independent variables with price. Itron was aware of this when they stated in reference to the BGE and ComEd zones, "...it was important to account for price in order to isolate issues associated with economic scale drivers".

Recommendation 2 proposes to include price into the peak load models by examining graphs of average revenue data from EIA-826 data and including binary variables for those years and zones where it is decided that a "significant" change in price occurred. This approach is unacceptable for three reasons.

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<sup>5</sup> IBID, page 33.

<sup>6</sup> IBID, page 25.

- **The decision to include only “significant” changes in price is arbitrary and capricious.**

Economic theory, and common sense, suggests that price changes have an impact on behavior – not just big price changes. In terms of electricity use, an argument can be made that the actual price change isn’t important but, the perception of the price trend is what determines behavior. This is what Itron is trying to capture with their “Price Shift” proposal. This approach, however, has significant problems associated with it.

First, commercial and industrial customers make a significant contribution to system peak load. These customers can be very knowledgeable consumers, track costs carefully, and are aware of and would react to price changes that Itron would determine to be insignificant.

Second, the searching for trend changes in a price graph does not correlate with consumer recognition of price changes. In 2005 Duquesne had a supply increase that increased the average residential bill by seven percent. In 2007, Duquesne had a significant increase in delivery rates that increased the average residential bill by 16.2 percent amid much publicity<sup>7</sup>. This price change did not show up as “significant” in the PJM/Itron “analysis”. The PJM/Itron process for looking for “significant” price changes simply does not work.

- **The decision to include price changes as a binary variable will distort any evaluation of the economic activity variable(s).**

My key concern for the proper incorporation of economic activity into the PJM load models is that the models will perform well in modeling 2008 and beyond. Will the models be able to model the recession and, as a result, be able to model the eventual economic recovery. This will not be possible if Price Shift variables are incorporated into the specification. If Price Shift variables are incorporated into the 2008 or 2009 as a binary variable for that year, any error in the impact of the economic variable will be absorbed by the Price Shift variable and assumed to be a price impact. This will result in understating the impact of the economic decline and, as a result, underestimating the impact of the recovery.

- **The PJM/Itron Process Results in Modeling Zones differently.**

The “Price Shift” proposal results in price effects being modeled in some zones not in others. This results in inconsistent forecasts where some zones loads are reduced and/or increased for price changes while others are not, again, given the methodology, on a completely arbitrary basis.

**Recommendation 3: Use an average of the Moody’s Economy.com & Global Insight baseline forecasts to generate the baseline economic forecast used in the Peak models.**

**Recommendation 4: Track vendor performance based on three-year ahead forecasts of the economic index. Adjust the relative vendor weights to be inversely proportional to their forecast standard errors.**

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<sup>7</sup> Leonard, Kim, “Utility Raising Rates by 16.2%”, Pittsburgh Tribune Review, December 1, 2006.

Frankly, I consider the accuracy of the national forecast assumptions used in the PJM load forecast as the least important of the modeling issues. Itron's rationale for Recommendation 3 is that:

"Over multiple forecast cycles, we expect that the average of the two baseline forecasts would be more stable and perhaps more accurate than either of the individual forecasts. Resulting in a more stable and perhaps more accurate long-term peak forecasts."<sup>8</sup>

Itron's reasoning does not include phrases such as: "we've examined the data" or "we've found". That analysis is contained in Recommendation 4 which is to occur after Recommendation 3 is implemented. I can't understand why you would implement a change that you have no clue (at least one that's supported by data) as to what its impact will be.

Another issue with this proposal has to do with variance analysis. Both Global Insight and Economy.com have forecasts that are based on their modeling framework and are internally consistent. I'm not sure that an average of the two forecasts independent variables would result in a forecast that would be an average of the dependent variables. As a result, it wouldn't be clear exactly what the basis for the "averaged" economic forecast is or why the actual has deviated from it.

**My Recommendation:** Do Recommendation 4 and then decide, based on the data, whether to do Recommendation 3.

**Recommendation 6: Explore approaches that interact HDD and CDD variables with economic driver that weight the residential and commercial economic factors more heavily in the economic index. Ideally, these drivers would account for end-use saturation and efficiency trends, as well as different sector weighting.**

**My Recommendation:** I agree that this should be explored sooner rather than later.

My conclusion after examining the PJM models is that the specification needs to be modified to project peak loads in a period of changing price, economic, demographic, and technological trends. Unfortunately, I don't believe that the Itron recommendations address this need adequately.

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<sup>8</sup> McMenamin, J. Stuart, Monforte, Frank A., Fox, Eric, and Sukenik, Andy, (2010), Page 49.