Simtec News

A Newsletter for Users of The RTSim Generation Simulation Software

Volume 3, Number 1

Simtec News is published three times a year by Simtec, Inc. for RTSim software clients. RTSim provides detailed hourly simulation of the real time operation of electrical generating systems and includes extensive market analysis.

For additional information on the RTSim software package please contact:

Simtec, Inc.
Suite 210
8001 Excelsior Dr.
Madison, WI 53717

Phone:
(608) 827-0377

E-mail:
simtec@itis.com

Fax:
(608) 827-0713

Winter, 1999

Principles of Electric Market Price Forecasting

Last summer's electric price shocks has produced a plethora of articles on electric price forecasting. Generally the articles are full of jargon of the trade (which we often use to isolate ourselves from other ideas and input); often ignore the realities of the electrical supply system; and provide little practical help for selecting a forecasting method. This article will attempt to cut through the word fog and provide a checklist of characteristics that should be included in any reasonable price forecasting methodology. If the methodology you are currently using does not contain these characteristics, you may want to consider looking for a more appropriate method.

Probabilistic Price Forecast

If you are asked to produce a price forecast for hour ending 13:00 on July 27, 1999, what is the very best forecast that you could produce? The ultimate forecast would be a probability distribution function. The probability distribution would provide a range of possible outcomes along with the probability of each price occurring. From such a forecast you can determine the price that will most likely occur. More importantly, you can determine the confidence intervals for different price ranges. For example, with a probabilistic price forecast, you could state that the most probable price will be 55 $/

...continued on page 2

RTSim Market Estimator

RTSim is comprehensive generation analysis software capable of solving many generation analysis problems including maintenance optimization, emission optimization and optimal market integration. Integral to these analyses is the capability to forecast market prices. The RTSim package includes two forecasting methods: a statistical forecast based on historical data and a multi-regional analysis of costs and market behavior. The multi-regional analysis is implemented using the RTSim Market Estimator. The following evaluates the Market Estimator relative to the checklist developed in the above article.

- ***The price forecast must be presented as a probability distribution.***

The hourly price forecasts developed with the Market Estimator for each type of commodity (next-hour economy and next-day economy) for each region are statistical distributions. The output of the Market Estimator is fully integrated with the input of all other features of RTSim to minimize data handling.

- ***The price forecast must include, either implicitly or explicitly, hourly load forecasts for all significant regions, generation availability, transmission***

...continued on page 7

Principles of Market Price Forecasting (cont.)

(Continued from page 1)

MWH or that you are 67% confident that the price will be between 50 and 60 $/MWH. You could even state the probability that you will lose money if you lock into a specific price now for delivery during the forecasted period. With this information, you can calculate the most profitable maintenance schedule, the likely profits from a potential sale, or the potential risks (losses) of that potential sale (How you actually use probabilistic price forecasts when making such calculations is important but left for a future article.)

Why can't we be more precise and produce a forecast of say 53.2 $/MWH? The answer lies in the fact that the factors affecting electric price forecasts such as weather can not be forecasted with any certainty but must be forecasted as a probability distribution. As a result, the price forecast must be made on that same basis. This is the first item in our checklist: ***the price forecast must be presented as a probability distribution***. To present the price forecast as simply a "point" forecast prevents the assessment of the potential risks of alternative decisions.

"Factors affecting electric price forecasts such as weather can not be forecasted with any certainty"

One thing that is helpful in the current rash of articles on price forecasting, is that there is a general consensus on the key factors that affected the price of electricity last summer. These are (1) the unusually high demand in certain load centers, (2) the unavailability of generating capacity in certain regions, (3) the unavailability of transmission facilities both to move energy from certain generating units and to move power from regions of excess to regions of shortage, and (4) marketing behavior. It was the convergence of these conditions that caused the extreme prices of last summer. Obviously, these factors should be included in any credible electric price forecast.

Probabilistic Demand Forecasts

A contributing factor to the high prices of last summer was that the actual demands were higher than the forecasted demands. Forecasting future energy use has always been critical in the electric utility industry. However, the deregulation of pricing places greater emphasis on appropriate forecasting particularly during high load periods when shortfalls of supply create wildly fluctuating prices.

Future energy demands are a function of many factors. Number of residential customers, appliance saturation, commercial activity, type of industrial base and the general state of the economy all affect energy use. However, these types of factors are not weather sensitive and normally have relatively long-term cycles and/or trends that can be relatively accurately forecasted. The difficult factors to forecast accurately are the weather sensitive effects. Because weather can not be accurately forecasted, weather temperature loads can not be.

The best one can do with temperature sensitive loads is to develop a statistical forecast of this load; that is, develop a forecast of different load levels with different probabilities of occurring. This forecast is a combination of the probability of different weather conditions occurring combined with the effects of these different weather conditions on consumption.

Considering that hourly price forecasts are necessary, hourly probabilistic load forecasts are required. Developing probabilistic hourly load forecasts is no simple matter. Yet, that is what is required if one is to make a credible hourly price forecast. We now have the second item in our checklist: ***the hourly load forecast must be represented statistically either implicitly or explicitly.***

"The best one can do with temperature sensitive loads is to develop a statistical forecast of this load."

If you are developing a statistical price forecast by analyzing historical price data, the weather data are included implicitly. You must be sure that the historical data contains a representative range of weather data or that the data has been corrected for a representative weather distribution. If you are developing a statistical price

forecast by analyzing the loads, generation and transmission capacity, the development of an explicit statistical load forecast is required.

A corollary to this checklist item is that ***the statistical load forecasts must be properly correlated among all regions being analyzed.*** For example, if you are analyzing how your area interacts with ten different areas or markets around your area, you should be developing statistical load forecasts for each area. Those forecasts, however, can not be made independently. They must be correlated to the extent that the weather is correlated among the regions.

If your are experiencing a summer heat wave in your area, you not want to be calculating market prices assuming that the neighboring areas have moderate weather unless that is what occurs in reality. Normally if your area is experiencing a heat wave, your neighboring utility is also experiencing the same heat wave and the same extreme load pattern. Statistical load forecasts for different areas must be correlated to the extent that they are in reality. Failing to include this correlation will result in market prices being drastically underestimated during extreme weather patterns.

The weather correlation among regions must also be included when developing price forecasts based on historical price data. Market prices are normally correlated with weather. If you are developing market prices for different markets or regions, those forecasts must be correlated to the extent that the weather patterns are correlated.

A final word on load forecasts. You can not simple pick a high forecast and look at the worst case condition. What is the difference between assuming that future prices are going to be around 80 $/MWH, entering into a purchase for 70 $/MWH and then finding the market price to actually be 50 $/MWH or assuming future prices to be 30 $/MWH, making a future sale for 40 $/MWH and then finding the market price to be 60 $/MWH? In both cases, a faulty forecast cost you 20 $/MWH transacted. You will want to use a statistical price forecast to accurately determine the range and probability of outcomes.

Probabilistic Generating Capacity by Region

"If you are developing a statistical price forecast by analyzing the loads, generation and transmission capacity, the development of an explicit statistical load forecast is required"

A key factor in determining market price is unit availability. The third item in the checklist is that ***the statistical availability of generating capacity must be properly represented***. Most price forecasting methods recognize generating availability. However, often the capacity is represented as an average and not as a probability distribution.

For example, a region's incremental/decremental costs will be calculated for a statistical distribution of generation availability. Rather than keeping the resulting costs as a distribution and calculating a distribution of market prices, the cost distribution will be averaged and the average price used to calculate only one hourly market price. The extremes in market price are simply ignored. These extremes can be of significant value as demonstrated by the events of last summer.

If you are developing a statistical price forecast by analyzing historical price data, the generating unit availability data are included implicitly. You must be sure that the historical data contains a representative range of availability data or that the data has been corrected for the expected unit availability. Forecasting market prices over several years using historical price data is tricky at best. How do you account for the effect of significant load growth and the installation of new capacity? These problems normally limit the use of historical price data to the forecasting the next 2-3 years.

If you are developing a statistical price forecast by analyzing the loads, generation and transmission capacity, the inclusion of explicit unit availability is somewhat easier. Analysts routinely use full and partial forced outage rates of generating units to simulate generating unit availability. However, trying to identify your neighbors' expansion or marketing plans and include those plans into a long-term analysis is difficult at best.

Keep in mind that generating unit availability is not simply a function of forced outage. Maintenance schedules, fuel limits and emission constraints also affect hourly prices.

...continued on page 4

Principles of Market Price Forecasting (cont.)

(Continued from page 3)

Startup costs and cycling constraints affect the availability of units during different hours of the day. Correct simulation of unit startup and cycling constraints need to be included to properly estimate the hourly price changes.

Unlike demand, unit availability from area to area is normally not correlated from region to region. The exception could be the long-term availability of hydroelectric energy where the amount of rainfall determines the available energy.

Probabilistic Transmission Availability

Regardless how much generation capacity is available, it is of little value if the transmission capability is not available to bring the energy to the load. The availability and access to transmission capability is the lifeblood of electric energy market. Transmission capability shapes the marketing of electrical energy by determining where energy can be sold and who can actually make sales in a particular region. As a result, **transmission has a major influence on electrical market prices and must be accurately represented** in the price forecasting method. This item on the checklist has several corollaries.

Transmission capability must be uncoupled from the generation. Historically, transmission was tightly integrated with generation. Recent deregulation, in an effort to promote competition, has separated the operation of the transmission capacity from the operation of the generation capacity. Now a transmission path to a specific market can be purchased from a given utility and used to compete directly with that utility's generation. However, most multi-regional modeling techniques do not include this added competition but continue to model the transmission and generation as tightly integrated.

What the uncoupling of transmission means is that any supplier of electrical energy can sell directly to any market providing that the necessary transmission path is available. This complicates market price forecasting because now there are many more buyer/seller combinations that must be considered when forecasting market price. If these additional buyer/seller combinations are not considered when forecasting market price, the forecasted market price can not be considered valid.

Another complicating factor of uncoupling generation from transmission is that now more alternative transmission paths may theoretically exist. To determine to costs of supplying energy to a distant region, each possible transmission path must be evaluated to find the least cost path after considering losses and wheeling charges. Again, most multi-regional modeling techniques do not include this added complexity.

Alternative transmission paths become more important once transmission outage is considered. **Transmission outage has a major impact on market price and must be considered in any market price forecast**. Transmission outages occur because of equipment failure, line maintenance, lighting strikes, tornadoes, ice storms, train derailments and many other events. Outage data similar to full and partial forced outage rates of generating unit are required to proper model the availability of transmission facilities on market prices.

Transmission outage not only affects the ability to market in a specific area and the losses and wheeling costs, but also the use of alternative transmission paths. This may affect your access to certain markets as other suppliers attempt to access other markets. The transmission grid is a complicated web of competing access. The degree of access to different markets is a key factor in determining the market price. Careful representation of transmission capability including the competing interests of different marketers must be included in a credible price forecast.

"Transmission capability shapes the marketing of electrical energy by determining where energy can be sold and who can actually make sales"

Interaction of the Key Variables

Demand, generation availability and transmission availability directly affect market price. However, it is the interaction of these variables that really sets the market price.

The price forecasting method must consider numerous combinations of demand, generation availability and transmission availability through their full range of probable outcomes.

This range of conditions will occur in the real world. The actual market price is not dependent on just the level of generation ability but also the current weather conditions (which, in part, define load) and the availability of generation in other regions and the current transmission capability to exchange energy with other regions.

For example, if there is an unusually large amount of generation forced out in a region but the weather conditions are moderate and transmission capability available to import available energy from other regions, price will be moderate. An extreme value in any one variable does not necessarily result in an extreme market price. However, if the generation outage remains high as the summer temperature (and load) begins to increase or transmission import capability declines, market prices begin to increase. The extreme market prices occur when generation outages are unusually high, load is unusually high and transmission import capability or energy available from other regions is unusually low.

Only when a full range of combinations of variables is examined and the probability of each combination determined can the price/probability curve be calculated for each hour. This is the level of detail that is needed to make an accurate price forecast

Market Behavior

Demand, generation availability and transmission are important variables necessary to establish market price. These variables determine the cost and availability of energy to meet the load. However, cost and general availability alone do not determine price. **Market behavior plays a critical role in determining the price and must be fully integrated into the market price forecast.**

To illustrate market behavior consider the Christmas toy market. If there are several "in" toys and all are relatively available, then there are several options for consumers. Prices will be competitive. Under such conditions, actual costs of manufacturing and marketing are the primary factors in setting the price.
However, sometimes 20 million kids perceive a particular toy as highly desirable but only 10 million were manufactured. Now a perceived shortage exists as 20 million sets of parents scramble to complete their shopping lists. Prices can rise to several times the actual costs to allocate the shortage. Other times a pparticular toy may not prove desirable and its price will be slashed to well below costs in an attempt to encourage demand and minimize loss.

These same **general market patterns are found in the electric market and must be included in the price calculation**. If there are no perceived spinning reserve violations or actual shortfalls, a general bidding process based on marginal production costs can be used to estimate regional prices. If there are several potential regional suppliers and limited buyers, the

on-peak hours. Without detailed startup/cycling analysis, market price forecasts will not be reliable simply because the units online will be incorrect and the wrong unit will assumed to be on the margin.

Second, the issue of unit commitment raises the issue of what type of market is actually being priced. There are three basic types of markets: longer-term bilateral contracts, next-hour economy and next-day economy. Longer-term bilateral contracts are normally priced individually and not by using general market price forecasts. (However, the benefits of a bilateral contract need to be compared to the potential profit and risk of competing next-day and next-hour economy transactions.)

Next-hour economy transactions are those transactions that are generally one hour in duration. Because of its short duration and unplanned nature, this type of transaction does do not directly affect the commitment of steam unit (which are usually the lower cost units). Pricing for next-hour economy transaction is normally based on the marginal unit that can be ***dispatched***.

Next-day economy transactions are those transactions that are normally several hours in duration and are entered into several hours before the start of delivery (normally the previous day). Because these transactions can be planned, this type of transaction will directly affect which units are committed. Pricing for next-day economy transactions is normally based on the marginal unit that can be ***committed*.**

Because pricing for next-hour economy transaction is normally

...continued on page 6

Principles of Market Price Forecasting (cont.)

(Continued from page 5)

based on the marginal unit that can be dispatched while pricing for next-day economy transactions is normally based on the marginal unit that can be committed, it is critical the pricing structure be identified with the type of economy transaction it should be used for. This critical distinction is one of the most misunderstood concepts in the forecasting of electric market prices.

This misunderstanding develops because many analysts do not understand the operation of electric generating systems. They make no distinction between the planned commitment of units and the actual dispatch of units. They make no distinction between next-day economy transactions that can affect the planned commitment and dispatch of units and next-hour economy that simply affect the dispatch of the units. A next-day economy transaction is a different commodity than a next-hour transaction. The two different commodities require a different market price forecast.

Checklist Summary

A reasonable price forecasting methodology should include the following:

- ❑ The price forecast must be presented as a probability distribution.
- ❑ The price forecast must include, either implicitly or explicitly, hourly load forecasts for all significant regions, generation availability, transmission availability and market behavior.
- ❑ The hourly load forecast must be represented statistically.
- ❑ The statistical load forecasts must be properly correlated among all regions being analyzed.
- ❑ The statistical availability of generating capacity must be properly represented.
- ❑ Transmission capability has a major influence on electrical market prices and must be accurately represented.

"There are three basis types of markets: bilateral contracts, next-hour economy, and next-day economy."

- ❑ Transmission capability must be uncoupled from the generation.
- ❑ Transmission outage has a major impact on market price and must be considered in any market price forecast.
- ❑ The price forecasting method must consider extensive combinations of demand, generation availability and transmission availability through their full range of probable outcomes.
- ❑ Market behavior plays a critical role in determining the price and must be fully integrated into the market price forecast.
- ❑ General market behavior patterns must be included in the price calculation.
- ❑ The simulation model must be accurate enough to properly simulate generation unit startups.
- ❑ Different commodities require different market price forecasts; the method must be applicable to the specific commodity.

If the methodology you are currently using does not contain these characteristics, you may want to consider looking for a more appropriate method.•

RTSim Market Estimator (cont.)

(Continued from page 1)

availability and market behavior.

The hourly price forecasts of the Market Estimator explicitly include hourly load forecasts of all regions. Generation availability is calculated in great detail and includes full forced outage, partial forced outage, scheduled maintenance, fuel limitations, and startup constraints. Transmission availability includes the full and partial outages and the competing use by other regions and transactions. Market behavior includes detailed bidding logic for normal markets and rationing pricing during perceived and actual shortages.

- ***The hourly load forecast must be represented statistically.***

The RTSim package includes integrated capability to develop and implement statistical hourly load forecasting. This capability includes data conversion routines to minimize data handling.

- ***The statistical load forecasts must be properly correlated among all regions being analyzed.***

The statistical load forecasts for different regions can be correlated or un-correlated for hourly weather.

- ***The statistical availability of generating capacity must be properly represented.***

The statistical availability of generating units is represented in great detail. Full and partial forced outage, including a probability distribution of the duration of the outage, are represented with a Monte Carlo analysis. Scheduled outage is included and can be optimized with the RTSim package. Fuel limitations including fuel deliveries and inventory are calculated by Monte Carlo iteration. Capacity deratings due to fuel switching and other factors can be used. The RTSim package is based on commitment model logic for determining commitment/dispatch. This logic is significantly more detailed than logic in production cost models and provides a more accurate analysis of startup and cycling constraints.

- ***Transmission capability has a major influence on electrical market prices and must be accurately represented.***

Transmission capability among regions can be defined in detail. Twenty different regions can be analyzed at one time with direct transactions between any or all regions for a total of 380 different transactions. Each different transaction can have three unique transmission paths. Each transmission path has its own defined loss and wheeling costs. Each transmission path is made up of one to three transmission links that may or may not be shared with other transmission paths. Each transmission link has a defined hourly bi-directional rating and a probability distribution of outage driven by a Monte Carlo analysis. Given this level of detail, the effect of complex transmission limitations on market prices can be analyzed.

- ***Transmission capability must be uncoupled from the generation.***

...continued on page 8

RTSim Market Estimator (cont.)

(Continued from page 7)

In the Market Estimator, transmission capability is completely uncoupled from generation. Any region can sell directly to any other region.

- ***Transmission outage has a major impact on market price and must be considered in any market price forecast.***

The Market Estimator has a detailed specification and analysis of transmission outage and capacity limitations. A total of 1200 transmission links can be specified. Each link has a defined hourly bi-directional rating and a probability distribution of outage driven by a Monte Carlo analysis. Links are combined to make transmission paths over which energy can be transferred between any two regions. The same transmission link may be used in several different paths to define the competing uses of different transactions.

- ***The price forecasting method must consider combinations of demand, generation availability and transmission availability through their full range of probable outcomes.***

The Market Estimator considers an extensive combination of hourly demand, generation availability and transmission availability through their full range of probable outcomes. In a typical run for a year, approximately 50,000 combinations of load levels, generation availability and transmission availability are evaluated. The analysis can be repeated any number of times with a different set of 50,000 combination each time.

- ***Market behavior plays a critical role in determining the price and must be fully integrated into the market price forecast.***

The Market Estimator determines the costs in each region based on the demand, generation availability,

> *"The Market Estimator considers an extensive combination of hourly demand, generation availability and transmission availability through their full range of probable outcomes."*

transmission availability and transactions. After the cost and market condition is determined, the price is determined based on market behavior.

- ***General market behavior patterns must be included in the price calculation.***

Market behaviors that translate costs into market prices can either be normal bidding behavior or shortfall allocation behavior. Normal bidding behavior is assumed for a region when there is no perceived or actual shortfall of capacity; shortfall allocation is used when there is perceived or actual shortfall. The normal bidding behavior looks at the costs of the actual sellers and buyers and the costs of alternative sellers and buyers to set the transaction price. The shortfall allocation looks at the magnitude of the perceived or actual shortfall to set the price.

- ***The simulation model must be accurate enough to properly simulate generation unit startups.***

RTSim is a commitment model as which is significantly more detailed compared to a production cost model. A commitment model is detailed enough to evaluate commitment/dispatch decisions for the next few days. Such a model provides an accurate assessment of unit startups and unit cycling

- ***Different commodities require different market price forecasts; the method must be applicable to the specific commodity.***

RTSim can be used to evaluate three different electric market commodities: Bilateral contracts, next-day economy transactions and next-hour transactions. The two economy transactions require market prices. These prices can be forecasted with either the Market Estimator or with a statistical forecast method using historical price data.•