Reliability Analysis using PLEXOS®

Leading the field in
Energy Market Modelling

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Introduction

The PLEXOS® simulator is a powerful tool for performing reliability studies on electric power systems. The simulator can calculate the standard metrics of LOLP, LOLE, EDNS and EENS from the PASA simulation phase using convolution. However, PLEXOS can also use the detailed chronological simulation of ST Schedule to produce the same metrics via Monte Carlo.

Energy Exemplar adopted this approach in the valuation of Loss of Load Expectation (LOLE) for the market operated by ISO-New England, which covers the six states of New England in the northeastern US. The following describes this approach we used with PLEXOS.

How to setup PLEXOS for Reliability via Monte Carlo

In a reliability study we are only interested in whether or not the system can meet the electric load, and possibly ancillary services requirements, given all generation technical, transmission, fuel availability and other user-defined constraints. The dispatch order of generators and the system marginal price is not useful and thus we can simplify the simulation by removing all costs apart from the pseudo cost of unserved energy (Value of Lost Load or VoLL). To do so, simply mark all cost information with a Scenario and exclude that Scenario from your reliability Model run. Example of cost parameters include:

- Generator [Heat Rate] and [Load Point]
- Generator [VO&M Charge]
- Fuel [Price]
- Generator [Offer Price]

Having done this, the simulation will be less complex, with the objective function containing only costs of unserved energy, dump energy and perhaps reserve shortage.

Loss of Load Expectation (LOLE)

Normally we compute the Loss of load probability (LOLP) as a reliability metric. This is a measure of the probability that demand will exceed the capacity of the system in a given period and is expressed as a percentage. As noted above, the periods when demand exceeds supply is a shortage event. An alternative metric is the Loss of Load Expectation (LOLE), which is the number of days of outage or the number of times in a given period that the load will be greater than the demand. This can be expressed as LOLE = LOLP * N/24. A value of 1.0 LOLE over a single year signifies multiple periods or hours over the year in which there were shortages. It is unlikely these shortages occurred in a single day but likely over multiple hours over several or more days.

We used the Monte Carlo feature in PLEXOS to calculate the probability of the LOLE for each load probability forecast in the New England. The first calculation was to benchmark the ISO-New England Installed Capacity Requirement ("ICR") calculation for the study period, or in this case the 2017 Peak Load Forecast. The following demand forecast from ISO-NE's ICR report (see Table 1 below) was used for this analysis.

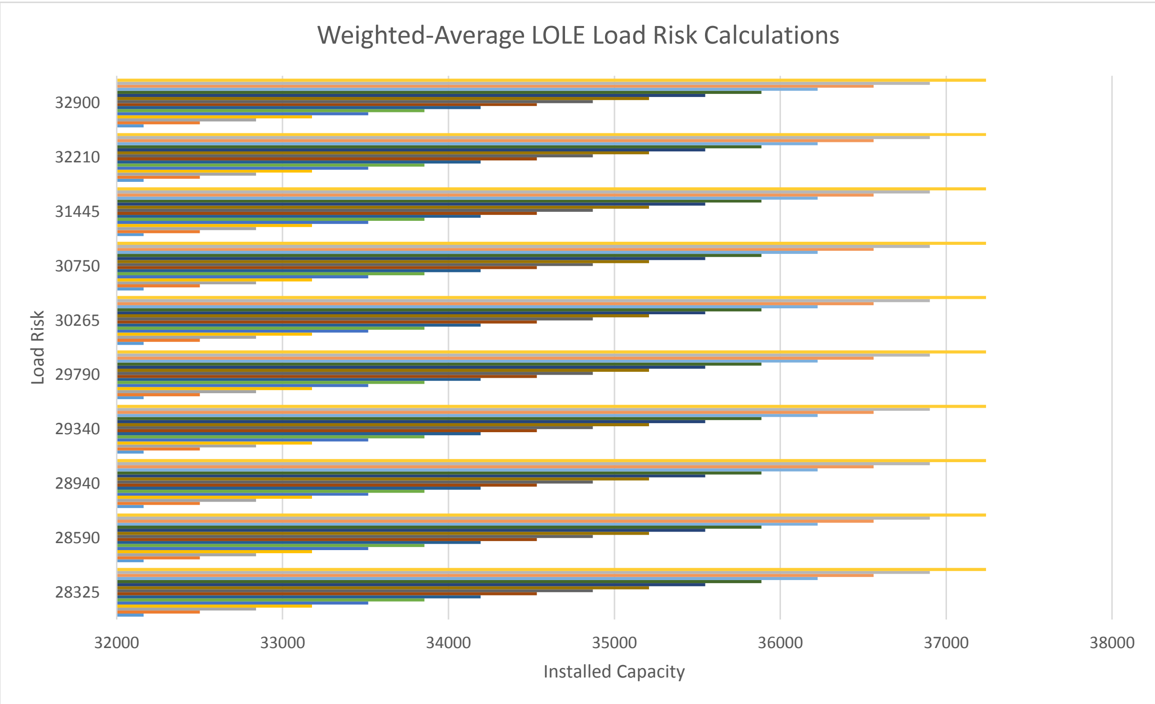
Table 1

Forecast Probability	10/90	20/90	30/70	40/60	50/50	60/40	70/30	80/20	90/10	95/5
2017 Peak Load Forecast	28,325	28,590	28,940	29,340	29,790	30,265	30,750	31,445	32,210	32,900

We then performed a LOLE calculation with an average load-weighted risk approach. We prepared a range of 16 different installed capacity levels in the ISO-NE control area and for each capacity level evaluated the average load weighted LOLE at each of the above 10 load probabilities in Table 1.

The following figure, shows the demand distribution on the y-axis and the capacity distribution on the x-axis. There are a total of 160 capacity and demand pairs in the following chart for which we computed the average load weighted LOLE for using PLEXOS®.

Figure 1



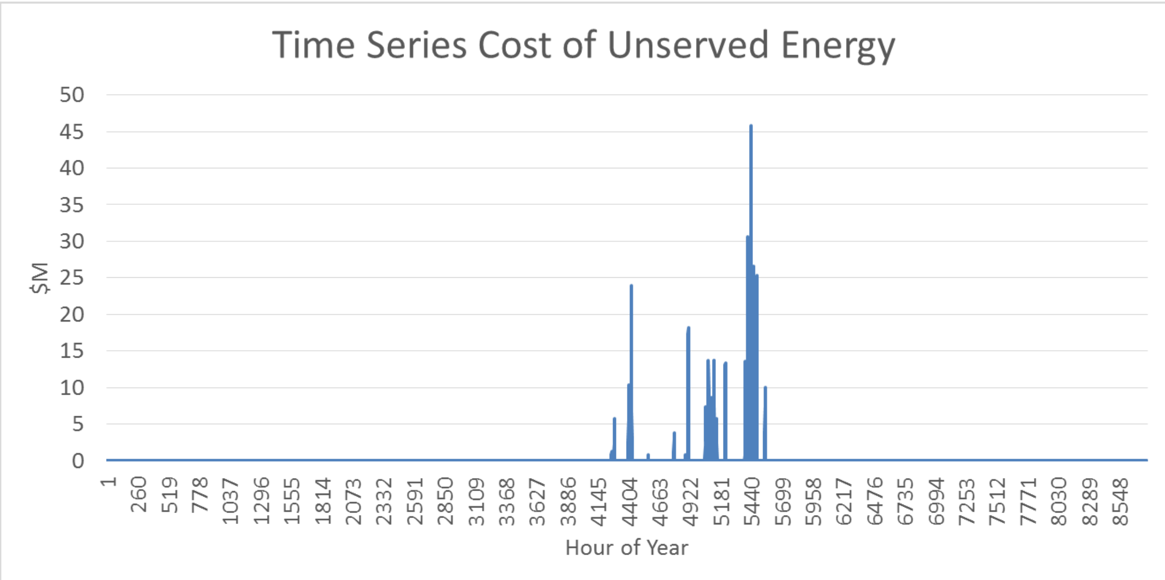
Then we prepared an average load weighted LOLE calculation for the 10 load probabilities for each capacity point and derived 16 average load weighted LOLE's as a function of installed capacity for the

ISO-NE control area. We derived a value of LOLE at the ISO-NE Net Installed Capacity Requirement (NICR) value of 0.1 day per year which is consistent with reliability criteria for NICR.

With the 16 LOLE calculations we were also able to compute the cost of lost load at each installed capacity level using the PLEXOS® 8,760 hour time series simulation. PLEXOS® estimates Unserved Energy (USE) at each hourly interval if demand is greater than generation, or a shortage event.

This can happen primarily in summer months with reduced thermal generator capacities in combination with load risk and forced generator outages. We then approximated the Value of Lost Load (VoLL). For this analysis, we assumed a VoLL $20,000/MWh. Figure 2, below, displays an example time series path of one of the load weighted risk replications for the 8760 hour simulation performed. We charted the cost of lost load in millions of dollars, which is the result of multiplication of the USE at each interval as described above by the value of VoLL selected above.

<u>Figure 2</u>



In Figure 2, the show an example of the 8760-hour simulation path for the peak demand and installed capacity pair with the cost of unserved energy is displayed on an hour by hour basis in millions of dollars. We ran 160 of these paths using Monte Carlo simulation and then took an average load weighted cost of lost load across the demand risk for each of the 16 installed capacity values.

Figure 3, below displays a curve of the LOLE calculations as a function of percent of Net Installed capacity Requirement ("NICR") for the New England Control Area as well as the cost of lost load as a function of percent NICR.

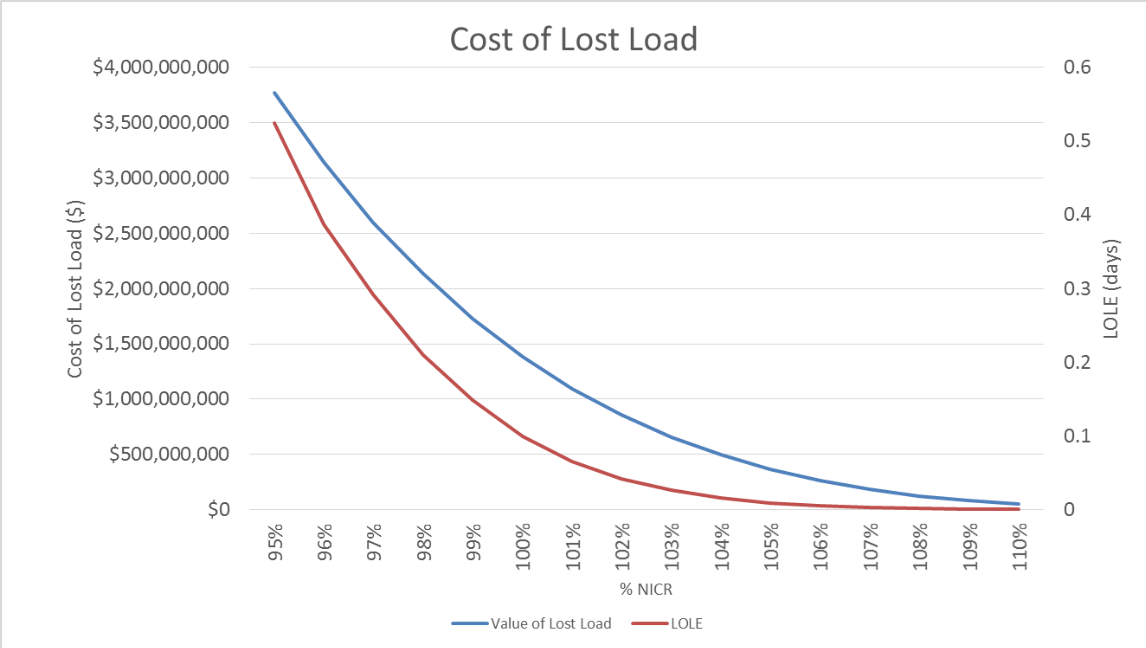


Figure 3

Figure 3 shows that the system LOLE reliability metric degrades rapidly for installed capacity values below NICR. Also, the cost of lost load increases rapidly below NICR.