ERCOT Target Reserve Margin Analysis

Prepared for:
Electric Reliability Counsel of Texas (ERCOT)

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Executive Summary

The Electric Reliability Counsel of Texas, Inc (ERCOT) is required to provide information to the Public Utility Commission of Texas and to the Texas State Legislature regarding the current and projected status of the Texas wholesale electricity market. The forecasted relationship between generation capacity and load is carefully scrutinized by regulatory authorities. In order to fulfill its responsibilities, ERCOT requires up-to-date analysis of the relationship between the probability of loss-of-load events and generating capacity reserve margins. The most recent Reserve Margin Analysis for ERCOT was completed in March 2002. Due to the changes in the ERCOT market since that time, including the retirement and mothballing of older gas-fired generation, the development of newer combined-cycle generation, and the increase in generation from uncontrolled units such as wind turbines, ERCOT solicited bids for an updated study which would provide an estimation of the effective load carrying capability (ELCC) of wind capacity and both loss of load probability (LOLP) and expected unserved energy (EUE). ERCOT enlisted Global Energy Decisions to conduct such a study.

The purpose of this study is to quantify the ELCC of wind capacity in ERCOT for reserve margin calculation purposes and to estimate LOLP and EUE at different reserve margin levels for the year 2008. Global Energy performed a stochastic analysis using the regional analytics module, MARKETSYM, to perform a study of the ERCOT system for the year 2008 where load, system wind generation, and unit forced outage were stochastic variables. The ERCOT Fall 2005 Reference Case data model was used as a basis for this study. This study:

- Presents ERCOT system characteristics as modeled in this study;
- Discusses the modeling methodology for determining ELCC of wind capacity;
- Discusses the modeling methodology for determining LOLP and EUE; and
- Provides the results of the ERCOT 2008 LOLP and Expected Unserved Energy (EUE) analysis.

In recent years, ERCOT has used a 12.5 percent planning reserve margin requirement. In calculating the planning reserve margin, there are several factors that need to be defined in order to accurately calculate the planning reserve margin. These factors are load forecast, installed capacity, load participation or load acting as a resource (LaaR), wind generation capacity, "mothballed" capacity, surrounding market import capability, capacity that generate on the local electric system or generate for an adjacent system, and retired capacity.[1] While most of these factors are fairly straight forward, one of the challenging factors is wind capacity in reserve margin calculation. The question is, "How much of installed wind capacity should I count towards reserve margin calculation." With ERCOT being rich in wind resources, this is a very important question. By 2008, ERCOT expects to have over 4,500 MW of nameplate wind capacity online and knowing how

[1]ERCOT Reserve Margin Update PowerPoint Presentation, April 7, 2005 - http://www.ercot.com/news/presentations/2006/op-reservemargin040705_final.pdf

much of that wind capacity can be included in reserve margin calculation is imperative for resource planning purposes.

Global Energy's MARKETSYM, a stochastic system dispatch model, was used to determine the ELCC of wind capacity and the LOLP and EUE at various levels of reserve margin for ERCOT in 2008. As a result of this study, Global Energy concluded that the ELCC of wind capacity is 8.7 percent of its nameplate capacity for reserve margin calculations. Global Energy then used this to calculate ERCOT reserve margins and develop the LOLP and EUE for the ERCOT region in 2008 using two different resource build-outs: one with gas turbines and one with coal steam turbines. Global Energy concludes that under the resource build-out scenario using only gas turbines that a 12.9 percent reserve margin yields a 1 day in 10 year Loss of Load Event (LOLE). Under the resource build-out scenario using coal steam turbines, Global Energy concludes that a 13.6 percent reserve margin yields a 1 day in 10 LOLE. The complete results of the LOLP and EUE analysis can be found in Section 3 of this report.

1 ANALYTICAL METHODOLOGY

Global Energy utilized its regional market analytics software module, MARKETSYM, to perform an ERCOT-wide stochastic analysis which was accomplished in two parts. The first part was determining what percentage of wind capacity could be counted toward reserve margin calculations (ELCC). The second part of the analysis was applying the ELCC of wind to the reserve margin calculation and running different reserve margins levels for the year 2008 and establishing LOLP and EUE at these levels. During both parts of this analysis, Global Energy stochastically simulated the hourly dispatch of ERCOT, where Monte Carlo draws were performed for 100 iterations in order to capture the impact of uncertainties of key factors. The key factors in this analysis were unit forced outages, weather related load volatility, and the unpredictability of available wind generation. Global Energy used its ERCOT Fall 2005 Reference Case data model as a basis for this study.[2]

1.1 ERCOT Simulation Topology

Global Energy utilized a single zone topology in this study as the objective was to evaluate all resource and load in ERCOT as a whole. This analysis did not include consideration of transmission constraints.

1.2 Stochastic Process

MARKETSYM is designed to simulate and provide output that enable the analysis of risks associated with serving load. The volatile inputs fed into the model for purposes of this analysis are load volatility, the unpredictability of available wind generation, and unit forced outages. Each of these volatile model inputs were treated stochastically in this analysis independent of one another. An explanation of each follows.

1.2.1 Load Stochastic Process and Volatility Parameters

Variability in load was modeled explicitly using a normal mean-reverting model as a component of the two-factor model described below. Mean reversion implies that after a load is initially disrupted (higher or lower), it will tend to revert back towards its expected value. The rate at which load will tend to revert to the expected value is an input to the process.

The stochastic model used to perform the stochastic draws on load is a two-factor model in which one factor represents short-term or temporary deviations and the other factor represents long term or cumulative deviations. Long-term effects include trends such as change in annual peak demand growth and other forces whose effects are of long duration, which follow a random walk. In the short-term, shocks may drive variables away from their long-term equilibrium level, but adjustments processes tend to pull them

[2] Changes to the base data of new station entry, and the status of mothballed and retired stations were made by recommendation from ERCOT staff.

back to their equilibrium or expected level. In other words, short-term shocks such as changes to load due to weather are mean reverting. The rate at which the random variable tends to revert to the expected value is an input to the process. The two-factor model combines these two processes.

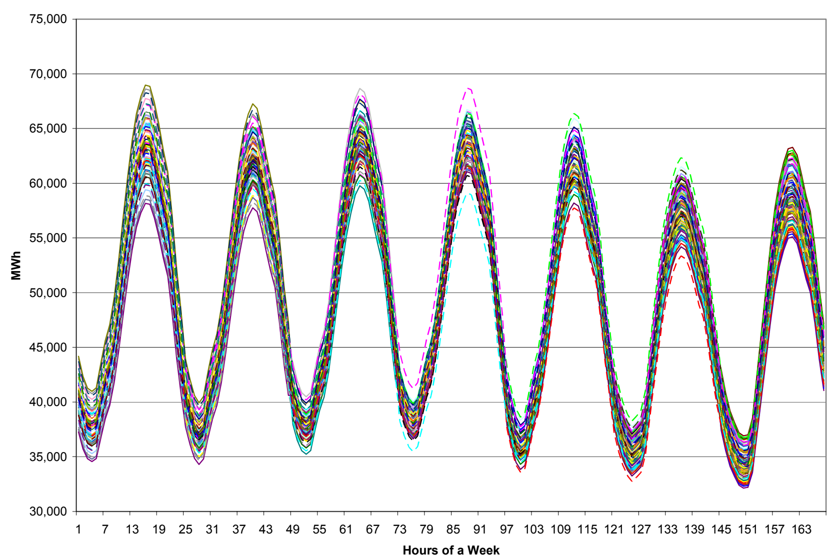
The volatility estimates for load in the ERCOT region are based on historical hourly load data from 1995-2004. The estimated short-term stochastic parameters for ERCOT load, used as inputs into the MARKETSYM stochastic analysis, are presented in Table 1-1 below. As a result of these stochastic parameter inputs, a distribution of load volatility is created. Figure 1-2 illustrates the stochastic draws for load for a representative week in August.

Table 1-1
ERCOT Load Stochastic Parameters

Season[3]	ERCOT Load	
2008	Alpha[4]	Sigma[5]
Winter	0.311	0.024
Spring	0.234	0.021
Summer	0.248	0.020
Fall	0.229	0.021

SOURCE: Global Energy.

Figure 1-1
ERCOT Load Distribution - 100 Iterations

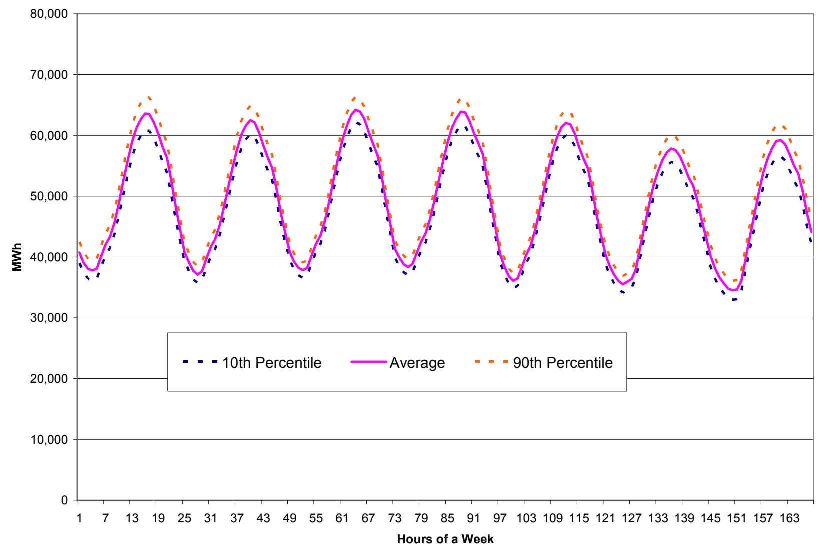


SOURCE: Global Energy.

[3] Season definition: Winter = December-February; Spring = March-May; Summer = June-August; Fall = September-November.
[4] Alpha is the mean reversion parameter.
[5] Sigma is the volatility parameter.

Figure 1-3 illustrates the 10th, Average, and 90th confidence intervals for a representative week in August.

Figure 1-2
ERCOT Load Distribution - Confidence Intervals



SOURCE: Global Energy.

1.2.2 Modeling of Volatility in Wind Generation

Using hourly wind shapes of expected available wind stations provided by ERCOT, Global Energy created 100 iterations of hourly wind patterns for use in the model that reflect the unpredictable nature of this resource type.[6] The stochastic data was developed external to MARKETSYM, and introduced during model simulation. The following method was used in creating the stochastic wind data:

1. The summation of all wind station generation was taken on each hour to develop an all system hourly available wind generation for each hour which resulted in one 8,784 (year 2008) shape. This aggregate hourly wind shape represented the available wind generation on each hour of 2008 for the entire ERCOT system.
2. To capture the randomness of wind generation, Global Energy developed a random number generator spreadsheet which randomized daily profiles within a month. For example, in creating the 24 hour by 100 iterations of data for January 1, the random number generator picked which hourly day profile in January to choose. Since January has 31 days, the random number generator chose any one of the 31 days of January for each of the 100 iterations for January 1. So for January 1, iteration 1 may use the hourly profile of day 30 of January, iteration 2 may use the hourly profile of

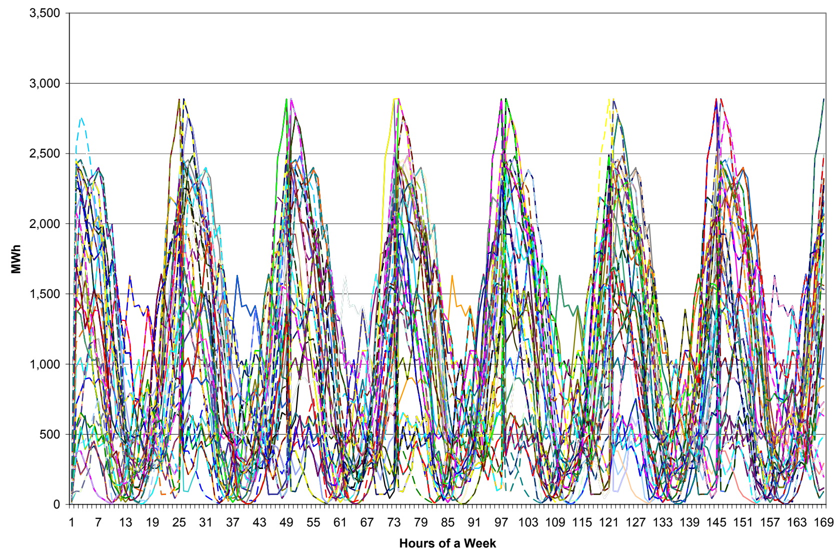
[6] The initial hourly wind shapes provided by ERCOT were developed by AWS Truewind LLC. The shapes were derived from 15 years of meteorological data using a combination of meteorological/topographical analysis. Wind speeds were then converted to wind farm generation using a power curve representing a composite of currently available turbine designs. The result was an average year of generation for modeled wind generation sites in ERCOT.

day 2 of January and so on. This process was continued until all days of the year for each of the 100 iterations was developed.

3. The randomized wind data was then fed into MARKETSYM through XML integration and included in the model simulation.

Figure 1-4 below illustrates the stochastic wind generation used in this study for a representative week in August.

Figure 1-3
ERCOT Stochastic Wind Data



SOURCE: Global Energy.

1.2.3 Variability in Unit Forced Outage

The uncertainty of unit forced outages was stochastically quantified on an hourly basis in the simulation model. Forced outages were represented by an equivalent annual forced outage rate at each generator and treated stochastically in Monte Carlo mode. Monte Carlo draws determine if a resource was on forced outage or not. If a unit has an expected forced outage rate of, for example, 5 percent, then the average outage hours for that unit over the 100 iterations is 5 percent of the time. The Monte Carlo draws are designed such that over a large number of random draws of unit outage, statistically one would expect the average hours of a unit being forced out during a year to be 5 percent. However, statistically it is possible that over 100 iterations the average outage rate is slightly above or below the 5 percent number. This process results in different outage draws on each of the 100 iterations performed in this analysis capturing the uncertainty in available resources on any given hour.

1.3 ELCC OF WIND CAPACITY IN ERCOT

Global Energy used its MARKETSYM module to perform a stochastic analysis of the effective load carrying capability (ELCC) of wind in ERCOT. Determining the load carrying capability of wind capacity is important due its unpredictability. With the results of the ELCC test, it is possible to accurately calculate ERCOT's reserve margin for use in the LOLP and EUE analysis. As described above, the volatile inputs used in this analysis are: weather related load volatility, the unpredictability of available wind generation, and unit forced outages. Global Energy used the following method in determining the ELCC of wind capacity:

1. An initial MARKETSYM LOLP test was done to ensure there was enough unserved energy in 2008 for the ELCC test to have significance. The objective is to have a reserve margin that yields LOLP that is greater than the industry standard of 1 day in 10.
2. Through an iterative process of stochastic MARKETSYM simulations, generic pulverized coal stations were added to the data model until approximately 1 day (24 hours) in 10 years of unserved energy was reported.
3. Once the 1 day in 10 years of unserved energy criterion was met, one 550 MW generic pulverized coal station was removed from the study.
4. Through another iterative process of stochastic MARKETSYM simulations, generic wind capacity was then added until approximately 1 day in 10 years of unserved energy was reported.

As a result of the ELCC test, it was found that 6,300 MW of wind capacity was added to reach the same LOLP level as 550 MW of generic pulverized coal capacity. The ELCC analysis concludes that 8.7 percent of installed wind capacity should be counted in the reserve margin calculation. Table 1-2 summarizes the results of the ELCC test.

Table 1-2
ELCC Test Results

	Pulverized Coal Capacity (MW)	Wind Capacity (MW)	ELCC of Wind
1 Day in 10 Years of Unserved Energy	550	6,300	8.7%

SOURCE: Global Energy.

1.4 Determination of LOLP and EUE

Global Energy's LOLP analysis methodology is a marked improvement over traditional methods for determining LOLP. Where, in the past, company's often computed an annual LOLP index as the summation of daily probabilities (often termed the "daily risks") over the entire year being studied, Global Energy computes LOLP based on a stochastic production cost model simulation where all relevant factors and uncertainties are included in the simulation. The analysis predicts both the probability of not serving a specific amount of load, and in addition provides insights into the dimension and amount of required energy that would not be served—referred to as unserved energy or expected unserved energy (EUE). Global Energy's LOLP methodology calculates LOLP for each hour where the LOLP is the probability that available capacity in a given hour is less than load. As recommended by ERCOT staff, the primary metric used in accessing resource adequacy is Loss of Load Events (LOLE), where the objective is achieving a reserve margin that equates to a LOLE of 1 day in 10 years. LOLE is described later in this section.

1.4.1 Calculating the Reserve Margin

A number of questions arise when the objective is calculating an accurate planning reserve margin for a system. The common method of calculating planning reserve margin is represented by the following equation:

$$\frac{[(\text{Resources} + \text{Purchases}) - (\text{Peak Load} + \text{Sales})]}{(\text{Peak Load} + \text{Sales})}$$

Identifying and assigning a value to each of these components offers several "counting" questions. How much of wind capacity to you count in the calculation? How are mothballed units counted in the calculation of reserve margin? What is considered the peak load hour? How is import capability counted?

Peak Load: Peak load is generally the 50/50 (expected peak) of the control area. In this study, where ERCOT is modeled as a single zone, the 50/50 peak for the entire system occurs in August.

Resources: The maximum capacities (nameplate) of thermal and hydro stations that are in ERCOT are included in the calculation. Wind capacity is counted at 8.7 percent based on the ELCC of wind capacity analysis described earlier. Interruptible loads and demand side management programs are included as resources. Approximately 5,500 MW of mothballed units that are not expected to come back online before August 2008 have been omitted from the reserve margin calculation[7]. A list of installed generation resources used in this analysis is provided in Appendix A.

Imports and Purchases: In this study, only known power purchase agreements with outside markets were considered in the calculation of the reserve margin. Import capability was not counted as additional capacity.

Table 1-3 exhibits the expected load and resource balance in ERCOT in the year 2008.[8]

[7] Unit retirement and mothball station status assumptions were provided by ERCOT staff.
[8] Peak load is calculated from the stochastic simulation as the average of peaks under each of the 100 iterations. Thermal capacity total reflects expected retirements and mothball unit status based on information provided by ERCOT staff. Hydro capacity was counted at maximum capacity. Wind is counted at 8.7 percent of total expected installed wind capacity in 2008. Purchases represent known scheduled imports from markets outside of ERCOT.

Table 1-3
2008 ERCOT - Expected Reserve Margin

2008 L&R	MW
Peak Load	64,367
Resources	
Thermal	71,742
Hydro	554
Wind	278
Purchases	54
Total Resources	**72,628**
Reserve Margin	**12.8%**

SOURCE: Global Energy.

1.4.2 Execution of LOLP and EUE Analysis

In order to perform this study, it is necessary to run the stochastic analysis at several levels of supply reserve. As such, additional supplies need to be added in order to move the supply reserve level from one level to a higher level of reserve. In this study, Global Energy performed two LOLP and EUE studies using different resource types to increase reserve margin levels: one using gas turbines and the other using pulverized coal steam turbines. Table 1-4 exhibits the key operational differences between the two resource types that affect the results of the LOLP and EUE analysis.

Table 1-4
Key Operational Differences

Resource Type	Max Capacity	Forced Outage Rate
Pulverized Coal ST	500	6%
Gas Turbine	180	2%

SOURCE: Global Energy.

The reserve margin levels used in this study for the LOLP and EUE analysis are: 10 percent, 12 percent, 14 percent, 16 percent, 18 percent, and 20 percent. In the case of achieving a 10 percent reserve margin, since the base case resource and load resulted in a reserve margin greater than 10 percent, Global Energy increased load to achieve the 10 percent target reserve margin level. Beginning at the 10 percent reserve margin, resources were added to meet the next studied target reserve margin.

The following outputs are produced and reported in this study:

- Loss of Load Events (LOLE) – A loss of load event is described as any single hour or group of consecutive hours where load exceeds available resources. For example, 1 hour alone of unserved energy constitutes a LOLE just as 5 consecutive hours of unserved energy constitutes an LOLE. Results are given as average Loss of Load Events in ten years.
- EUE as a function of planning margin – EUE is the average amount of ENS, measured in MWh, across all iterations of the stochastic simulation. Results are given as average MWh with EUE in ten years.

- LOLP as a function of planning margin – LOLP is tracked and reported by MARKETSYM. A Loss-of-Load hour is an hour where demand exceeds supply. Loss-of-Load hours do not indicate magnitude or duration of the loss-of-load. Results are given as number of hours with loss-of-load (24hrs) in ten years.

The next section reports the results of the LOLP and EUE analysis.

2 LOLP AND EUE RESULTS

This section reports the results of the LOLP and EUE studies for the gas turbine build-out scenario and the pulverized coal build-out scenario. The goal of the LOLP and EUE study was to determine what reserve margin would achieve a Loss of Load Event (LOLE) expected rate of 1 day in 10 years. A LOLE, as defined in the previous section, is defined as any single hour or group of consecutive hours where load exceeds available resources. In addition to LOLE results, Global Energy reports average MWh of unserved energy, average hours of ENS, and loss of load probabilities, at each of the reserve margin levels. All results are reported using the "1 day in 10 year" metric.

2.1 GAS TURBINE BUILDOUT SCENARIO

Table 2-1 provides detail on model results for the gas turbine build-out scenario. As can be gathered from the table, a reserve margin of approximately 12.9 percent yields a 1 day in 10 year LOLE using gas turbines as the build-out resource.

Table 2-1
Gas Turbine Scenario - LOLP and EUE Results

Reserve Margin[1, 2]	Average Loss of Load Events in 10 Years[3]	Average MWhs of ENS in 10 Years	Average Hours of ENS in 10 Years	Loss of Load Probability (%)
10.00%	5.1	9,020	9	0.011%
12.00%	1.4	2,570	2.6	0.003%
14.00%	0.5	515	0.9	0.001%
16.00%	0	0	0	0.000%
18.00%	0	0	0	0.000%
20.00%	0	0	0	0.000%

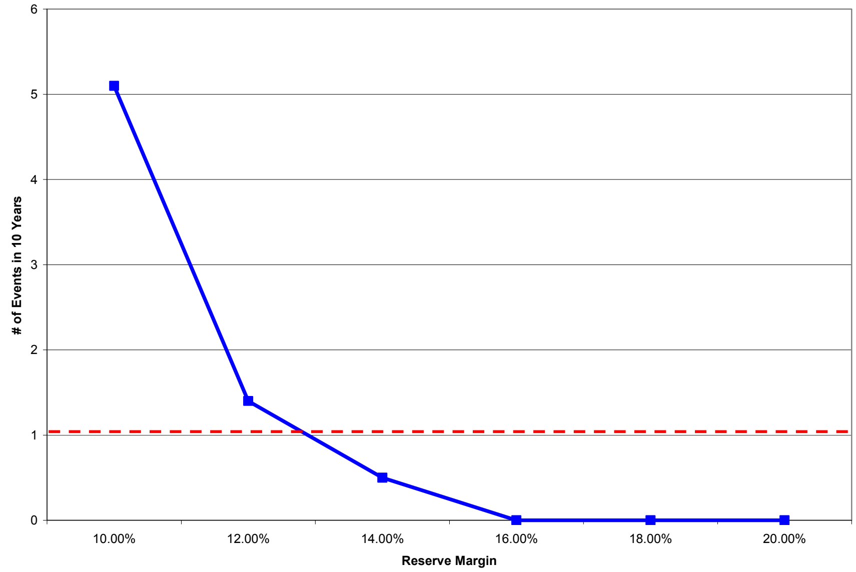
1. Reserve margins increased by adding approximately 1,300 MW of GT Gas capacity per 2% increase in reserve margin.
2. Wind generation counted at 8.7% of nameplate capacity.
3. Events with consecutive hours of ENS are counted as one event.

SOURCE: Global Energy.

While the results suggest at a reserve margin of 16 percent and greater, that the number of loss of load events is zero, in reality the probability of a loss of load event never reaches zero, no matter how much capacity is added to the system. The finite limit of 100 iterations used in this analysis, restricts the chance of a loss of load event which is reflected in Table 2-1 above.

Figure 2-1 below illustrates the LOLE at the different reserve margin levels. The intersection of the LOLE curve and the red dotted line represents the 12.9 percent reserve margin that yields a LOLE of 1 day in 10 years.

Figure 2-1
Gas Turbine Scenario - Loss of Load Events in 10 Years



SOURCE: Global Energy.

2.2 PULVERIZED COAL STEAM TURBINE BUILD-OUT SCENARIO

Table 2-2 provides detail on model results for the pulverized coal steam turbine build-out scenario. As can be gathered from the table, a reserve margin of approximately 13.6 percent yields a 1 Day in 10 year LOLE using pulverized coal steam turbines as the build-out resource.

Table 2-2
Pulverized Coal Steam Turbine Scenario - LOLP and EUE Results

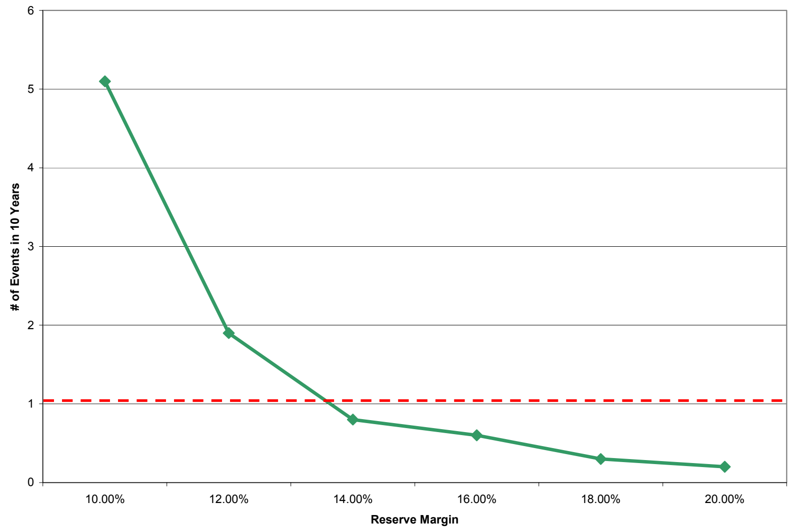
Reserve Margin[1, 2]	Average Loss of Load Events in 10 Years[3]	Average MWhs of ENS in 10 Years	Average Hours of ENS in 10 Years	Loss of Load Probability (%)
10.00%	5.1	9,020	9	0.011%
12.00%	1.9	5,800	4	0.005%
14.00%	0.8	2,589	2	0.002%
16.00%	0.6	916	1	0.001%
18.00%	0.3	237	0.3	0.000%
20.00%	0.2	93	0.2	0.000%

1. Reserve margins increased by adding approximately 1,300 MW of ST Coal capacity per 2% increase in reserve margin.
2. Wind generation counted at 8.7% of nameplate capacity.
3. Events with consecutive hours of ENS are counted as one event.

SOURCE: Global Energy.

Figure 2-2 below illustrates the LOLE at the different reserve margin levels. The intersection of the LOLE curve and the red dotted line represents the 13.6 percent reserve margin that yields a LOLE of 1 day in 10 years.

Figure 2-2
Pulverized Coal Steam Turbine Scenario – Loss of Load Events in 10 Years

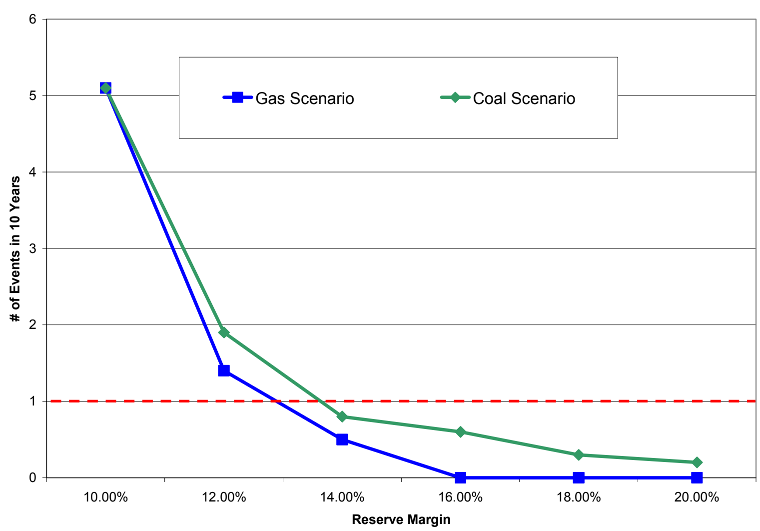


SOURCE: Global Energy.

2.3 Comparison of Gas and Coal Scenarios

Figure 2-3 illustrates the differences in LOLE between the gas and coal build-out scenarios. As can be seen in the graph, an LOLE of 1 day in 10 years is achieved with a lower reserve margin using the gas build-out.

Figure 2-3
Gas and Coal Scenario Comparison - Loss of Load Events in 10 Years



SOURCE: Global Energy.

The differences in results between the Gas and Coal build-out scenarios can be explained by two factors. The first factor is that gas turbines have a lower forced-outage rate than pulverized coal steam turbines, 2 percent and 6 percent respectively.

The second factor that causes differences in LOLE between the gas and coal build-out scenarios is the difference in size of the units being added. For example, in the gas scenario to transition from the 10 percent reserve margin to the 12 percent reserve margin, eight gas turbines of 162.5 MW are added. In the coal scenario to transition from the 10 percent reserve margin to the 12 percent reserve margin, three coal units are added, two at 500 MW a piece and one at 300 MW. The same amount of capacity is being added in the two cases, however the build-out in the gas scenario is more flexible. Consider the minimum MW amount of forced outage in each of the scenarios if one was to occur. During a forced outage, the gas scenario would experience a minimum loss of 162.5 MW while the coal scenario would experience a minimum loss of 300 MW. The gas build-out is more flexible because a single forced outages event will eliminate less of the available capacity.

In conclusion, due to the two factors described above, to achieve the same LOLE as the gas build-out scenario more coal capacity would need to be added to achieve the same LOLE.

APPENDIX A

Table A- 1
ERCOT 2008 Generation Resources - Summer Rating

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
A.V. Rosenberg 1a	240	CC	Natural Gas
A.V. Rosenberg 1b	240	CC	Natural Gas
Abbott TP 3	3	Hydro	Hydro
AES Deepwater 1	160	ST	Petroleum Coke
AES Wolf Hollow 1a	357	CC	Natural Gas
AES Wolf Hollow 1b	357	CC	Natural Gas
Amistad Dam & Power	70	Hydro	Hydro
Atascocita	7	IC	Biomass
Atkins 3	12	ST	Natural Gas
Atkins 4	22	ST	Natural Gas
Atkins 5	25	ST	Natural Gas
Atkins 6	50	ST	Natural Gas
Atkins GT 7	21	GT	Natural Gas
Austin	17	Hydro	Hydro
BASF Freeport 1	93	CG	Natural Gas
Bastrop Energy 1a	275	CC	Natural Gas
Bastrop Energy 1b	275	CC	Natural Gas
Bayou Cogen GT EN1	70	GT	Natural Gas
Bayou Cogen GT EN2	70	GT	Natural Gas
Bayou Cogen GT EN3	70	GT	Natural Gas
Bayou Cogen GT EN4	70	GT	Natural Gas
Baytown 1a	176	CC	Natural Gas
Baytown 1b	176	CC	Natural Gas
Baytown 1c	176	CC	Natural Gas
Big Brown 1	570	ST	Coal
Big Brown 2	560	ST	Coal
Big Spring 1	13	ST	Other
Big Spring Wind Power	4	WT	Wind
Blue Bonnet	4	IC	Biomass
Bosque 1	154	GT	Natural Gas
Bosque 2	154	GT	Natural Gas
Bosque CC 3a	253	CC	Natural Gas
Brazos Valley 1a	337	CC	Natural Gas
Brazos Valley 1b	337	CC	Natural Gas
Brazos Wind Farm	14	WT	Wind
Buchanan (TX)	49	Hydro	Hydro
Buffalo Gap Wind	31	WT	Wind
C R Wing Cogen Plant 1-3	200	CG	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Callahan Divide Wind	10	WT	Wind
Canyon	6	Hydro	Hydro
Cedar Bayou 1	750	ST	Natural Gas
Cedar Bayou 2	750	ST	Natural Gas
Channel Lyondell 1a	210	CC	Natural Gas
Channel Lyondell 1b	204	CC	Natural Gas
Clear Lake Cogen 1a	137	CC	Natural Gas
Clear Lake Cogen 1b	137	CC	Natural Gas
Clear Lake Cogen 1c	137	CC	Natural Gas
Cleburne Cogen 1	259	CC	Natural Gas
Coastal Plains	5	IC	Biomass
Coleto Creek 1	632	ST	Coal
Comanche Peak 1	1084	NP	Uranium
Comanche Peak 2	1124	NP	Uranium
Corpus Christi 1a	245	CG	Natural Gas
Corpus Christi 1b	245	CG	Natural Gas
Dansby 1	110	ST	Natural Gas
Dansby 2	46	GT	Natural Gas
Decker Creek 1	354	ST	Natural Gas
Decker Creek 2	448	ST	Natural Gas
Decker Crk GT 1	52	GT	Natural Gas
Decker Crk GT 2	52	GT	Natural Gas
Decker Crk GT 3	52	GT	Natural Gas
Decker Crk GT 4	52	GT	Natural Gas
Decordova 1	804	ST	Natural Gas
Decordova GT 1	75	GT	Natural Gas
Decordova GT 2	75	GT	Natural Gas
Decordova GT 3	75	GT	Natural Gas
Decordova GT 4	75	GT	Natural Gas
Deer Park Energy 1a	207	CC	Natural Gas
Deer Park Energy 1b	207	CC	Natural Gas
Deer Park Energy 1c	207	CC	Natural Gas
Deer Park Energy 1d	207	CC	Natural Gas
Delaware Mountain Wind	3	WT	Wind
Denison Dam	80	Hydro	Hydro
Desert Sky Wind Proj 1	7	WT	Wind
Desert Sky Wind Proj 2	7	WT	Wind
DFW Gas Recovery	6	GT	Biomass
Dow Chemical 1a	261	CC	Natural Gas
Dow Chemical 1b	261	CC	Natural Gas
Dow Freeport 1a	50	CG	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Dunlap TP 1	4	Hydro	Hydro
Eagle Pass	6	Hydro	Hydro
Ennis 1	343	CC	Natural Gas
Equistar Channelview 1a	244	CGCC	Natural Gas
Equistar Channelview 1b	244	CGCC	Natural Gas
ExTex LaPorte 1	40	GT	Natural Gas
ExTex LaPorte 2	40	GT	Natural Gas
ExTex LaPorte 3	40	GT	Natural Gas
ExTex LaPorte 4	40	GT	Natural Gas
Falcon Dam & Power	39	Hydro	Hydro
Fayette PP 1	580	ST	Coal
Fayette PP 2	580	ST	Coal
Fayette PP 3	445	ST	Coal
Forest Creek Wind	19	WT	Wind
Formosa Cogen	40	CG	Natural Gas
Forney Project 1a	294	CC	Natural Gas
Forney Project 1b	294	CC	Natural Gas
Forney Project 1c	294	CC	Natural Gas
Forney Project 2a	294	CC	Natural Gas
Forney Project 2b	294	CC	Natural Gas
Forney Project 2c	294	CC	Natural Gas
Freestone Energy 1a	244	CC	Natural Gas
Freestone Energy 1b	244	CC	Natural Gas
Freestone Energy 1c	244	CC	Natural Gas
Freestone Energy 1d	244	CC	Natural Gas
Frontera Project 1a	233	CC	Natural Gas
Frontera Project 1b	233	CC	Natural Gas
Frontier 1a	430	CC	Natural Gas
Frontier 1b	430	CC	Natural Gas
Gateway 1a	433	CC	Natural Gas
Gateway 1b	433	CC	Natural Gas
Gibbons Creek 1	462	ST	Coal
Graham 1	241	ST	Natural Gas
Graham 2	400	ST	Natural Gas
Granite Shoals	56	Hydro	Hydro
Greens Bayou 5	420	ST	Natural Gas
Grn Bayou GT 73	54	GT	Natural Gas
Grn Bayou GT 74	54	GT	Natural Gas
Grn Bayou GT 81	54	GT	Natural Gas
Grn Bayou GT 82	64	GT	Natural Gas
Grn Bayou GT 83	64	GT	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Grn Bayou GT 84	64	GT	Natural Gas
Guadalupe 1a	255	CC	Natural Gas
Guadalupe 1b	255	CC	Natural Gas
Guadalupe 2a	255	CC	Natural Gas
Guadalupe 2b	255	CC	Natural Gas
H 4	2	Hydro	Hydro
H 5	2	Hydro	Hydro
Handley 3	394	ST	Natural Gas
Handley 4	455	ST	Natural Gas
Handley 5	455	ST	Natural Gas
Hays San Marcos 1	242	CC	Natural Gas
Hays San Marcos 2	242	CC	Natural Gas
Hays San Marcos 3	275	CC	Natural Gas
Hays San Marcos 4	275	CC	Natural Gas
Hidalgo Energy 1a	244	CC	Natural Gas
Hidalgo Energy 1b	244	CC	Natural Gas
Horse Hollow Wind	71	WT	Wind
Houston Chemical 1	80	CGGT	Natural Gas
Indian Mesa Orion	7	WT	Wind
Ingleside Cogen 1a	103	CC	Natural Gas
Ingleside Cogen 1b	103	CC	Natural Gas
Inks	14	Hydro	Hydro
J K Spruce 1	555	ST	Coal
J T Deely 1	415	ST	Coal
J T Deely 2	415	ST	Coal
Jack Energy Facility 1a	258	CC	Natural Gas
Jack Energy Facility 1b	258	CC	Natural Gas
King Mountain Wind	24	WT	Wind
Lake Creek 2	230	ST	Natural Gas
Lake Hubbard 1	393	ST	Natural Gas
Lake Hubbard 2	533	ST	Natural Gas
Lamar Power 1a	245	CC	Natural Gas
Lamar Power 1b	245	CC	Natural Gas
Lamar Power 2a	245	CC	Natural Gas
Lamar Power 2b	245	CC	Natural Gas
Laredo 1	35	ST	Natural Gas
Laredo 2	34	ST	Natural Gas
Laredo 3	109	ST	Natural Gas
Leon Creek 3	65	ST	Natural Gas
Leon Creek Expansion 1	50	GT	Natural Gas
Leon Creek Expansion 2	50	GT	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Leon Creek Expansion 3	50	GT	Natural Gas
Leon Creek Expansion 4	50	GT	Natural Gas
Lewisville	3	Hydro	Hydro
LG&E Gregory 1a	207	CC	Natural Gas
LG&E Gregory 1b	207	CC	Natural Gas
Limestone 1	836	ST	Coal
Limestone 2	766	ST	Coal
Lost Pines 1a	251	CC	Natural Gas
Lost Pines 1b	251	CC	Natural Gas
Lyondell Cogen 1a	186	CG	Natural Gas
Lyondell Cogen 1b	186	CG	Natural Gas
Lyondell Cogen 1c	186	CG	Natural Gas
Magic Valley 1a	376	CC	Natural Gas
Magic Valley 1b	376	CC	Natural Gas
Marble Falls	36	Hydro	Hydro
Marshall Ford	107	Hydro	Hydro
Martin Lake 1	750	ST	Coal
Martin Lake 2	750	ST	Coal
Martin Lake 3	750	ST	Coal
Mesquite Wind	17	WT	Wind
Midlothian 1	218	CS	Natural Gas
Midlothian 2	218	CS	Natural Gas
Midlothian 3	218	CS	Natural Gas
Midlothian 4	218	CS	Natural Gas
Midlothian 5	218	CS	Natural Gas
Midlothian 6	218	CS	Natural Gas
Monticello ERCOT 1	565	ST	Coal
Monticello ERCOT 2	565	ST	Coal
Monticello ERCOT 3	750	ST	Coal
Morgan Creek 5	180	ST	Natural Gas
Morgan Creek 6	511	ST	Natural Gas
Morgan Creek CT1	70	GT	Natural Gas
Morgan Creek CT2	70	GT	Natural Gas
Morgan Creek CT3	70	GT	Natural Gas
Morgan Creek CT4	70	GT	Natural Gas
Morgan Creek CT5	70	GT	Natural Gas
Morgan Creek CT6	69	GT	Natural Gas
Morris Sheppard	24	Hydro	Hydro
Mountain Crk 6	120	ST	Natural Gas
Mountain Crk 7	120	ST	Natural Gas
Mountain Crk 8	550	ST	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Newgulf 1	88	CC	Natural Gas
Nolte	2	Hydro	Hydro
North Texas 1	18	ST	Natural Gas
North Texas 2	18	ST	Natural Gas
North Texas 3	40	ST	Natural Gas
O W Sommers 1	445	ST	Natural Gas
O W Sommers 2	435	ST	Natural Gas
Oklaunion 1	690	ST	Coal
Oyster Creek CC 1	55	CC	Natural Gas
Panda Odessa/Ector 1a	259	CC	Natural Gas
Panda Odessa/Ector 1b	259	CC	Natural Gas
Panda Odessa/Ector 1c	259	CC	Natural Gas
Panda Odessa/Ector 1d	259	CC	Natural Gas
Pasadena CG 1	150	CG	Natural Gas
Pasadena CG 2a	270	CG	Natural Gas
Pasadena CG 2b	270	CG	Natural Gas
Pearsall 1	25	ST	Natural Gas
Pearsall 2	25	ST	Natural Gas
Pearsall 3	25	ST	Natural Gas
Permian B GT 1	72	GT	Natural Gas
Permian B GT 2	72	GT	Natural Gas
Permian B GT 3	72	GT	Natural Gas
Permian B GT 4	69	GT	Natural Gas
Permian B GT 5	69	GT	Natural Gas
Permian Basin 5	115	ST	Natural Gas
Permian Basin 6	545	ST	Natural Gas
PH Robinson 2	461	ST	Natural Gas
Post Wind Farm	7	WT	Wind
Powerlane GRNV 1	20	ST	Natural Gas
Powerlane GRNV 2	27	ST	Natural Gas
Powerlane GRNV 3	42	ST	Natural Gas
R W Miller 1	75	ST	Natural Gas
R W Miller 2	120	ST	Natural Gas
R W Miller 3	208	ST	Natural Gas
R W Miller GT 4	104	ST	Natural Gas
R W Miller GT 5	104	ST	Natural Gas
Ray Olinger 1	80	ST	Natural Gas
Ray Olinger 2	110	ST	Natural Gas
Ray Olinger 3	150	ST	Natural Gas
Ray Olinger GT 4	76	ST	Natural Gas
Ray Roberts	1	Hydro	Hydro

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Rayburn CC 1a	67	CC	Natural Gas
Rayburn CC 1b	67	CC	Natural Gas
Rayburn CC 1c	67	CC	Natural Gas
Reliant Baytown	5	IC	Biomass
Rio Nogales 1a	258	CC	Natural Gas
Rio Nogales 1b	258	CC	Natural Gas
Rio Nogales 1c	258	CC	Natural Gas
Sam Bertron 1	174	ST	Natural Gas
Sam Bertron 2	174	ST	Natural Gas
Sam Bertron 3	230	ST	Natural Gas
Sam Bertron 4	230	ST	Natural Gas
Sam Bertron GT 1	23	GT	Natural Gas
Sam Bertron GT 2	13	GT	Natural Gas
Sam Rayburn 3	25	ST	Natural Gas
Sam Rayburn GT 1	11	GT	Natural Gas
Sam Rayburn GT 2	12	GT	Natural Gas
San Jacinto SES 1	81	CGGT	Natural Gas
San Jacinto SES 2	81	CGGT	Natural Gas
San Miguel 1	391	ST	Coal
Sand Hill CC 5a	275	CC	Natural Gas
Sand Hill GT 1	47	GT	Natural Gas
Sand Hill GT 2	47	GT	Natural Gas
Sand Hill GT 3	47	GT	Natural Gas
Sand Hill GT 4	47	GT	Natural Gas
Sandow 4	555	ST	Coal
Security	4	IC	Biomass
Silas Ray 10	45	GT	Natural Gas
Silas Ray 69	62	CC	Natural Gas
Silverstar 1	5	WT	Wind
Sim Gideon 1	140	ST	Natural Gas
Sim Gideon 2	140	ST	Natural Gas
Sim Gideon 3	340	ST	Natural Gas
South Texas 1	1280	NP	Uranium
South Texas 2	1280	NP	Uranium
Southwest Mesa 1	7	WT	Wind
Spencer 4	60	ST	Natural Gas
Spencer 5	66	ST	Natural Gas
Stryker Crk 1	176	ST	Natural Gas
Stryker Crk 2	517	ST	Natural Gas
Sweeny 1	88	CGGT	Natural Gas
Sweeny 2	90	CGGT	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
Sweeny 3	90	CGGT	Natural Gas
Sweeny 4	90	CGGT	Natural Gas
Sweetwater 1a	132	CC	Natural Gas
Sweetwater 1b	125	CC	Natural Gas
Sweetwater Wind	23	WT	Wind
T H Wharton CC 3a	166	CC	Natural Gas
T H Wharton CC 3b	166	CC	Natural Gas
T H Wharton CC 4a	166	CC	Natural Gas
T H Wharton CC 4b	166	CC	Natural Gas
T H Wharton GT 51	58	GT	Natural Gas
T H Wharton GT 52	58	GT	Natural Gas
T H Wharton GT 53	58	GT	Natural Gas
T H Wharton GT 54	58	GT	Natural Gas
T H Wharton GT 55	58	GT	Natural Gas
T H Wharton GT 56	58	GT	Natural Gas
Tenaska Lamar III 1a	117	CC	Natural Gas
Tenaska Lamar III 1b	117	CC	Natural Gas
Tessman Road	6	GT	Biomass
Texas City Calpine 1a	223	CG	Natural Gas
Texas City Calpine 1b	223	CG	Natural Gas
Texas City Green 2 1a	227	CG	Natural Gas
Texas City Green 2 1b	227	CG	Natural Gas
Thomas C Ferguson 1	420	ST	Natural Gas
TP 4	2	Hydro	Hydro
Tradinghouse Crk 1	565	ST	Natural Gas
Tradinghouse Crk 2	810	ST	Natural Gas
Trent Mesa Wind	13	WT	Wind
Trinidad 6	237	ST	Natural Gas
Twin Oaks Power 1	171	ST	Coal
Twin Oaks Power 2	172	ST	Coal
TX Wind Power 1	4	WT	Wind
V H Braunig 1	225	ST	Natural Gas
V H Braunig 2	240	ST	Natural Gas
V H Braunig 3	400	ST	Natural Gas
Valley ERCOT 1	177	ST	Natural Gas
Valley ERCOT 2	554	ST	Natural Gas
Valley ERCOT 3	390	ST	Natural Gas
Village Creek 1a	4	CG	Natural Gas
W A Parish 1	174	ST	Natural Gas
W A Parish 2	174	ST	Natural Gas
W A Parish 3	278	ST	Natural Gas

Table continued on next page.

Generator Name	Net Capacity (Peak)	Unit Type	Fuel Type
W A Parish 4	552	ST	Natural Gas
W A Parish 5	690	ST	Coal
W A Parish 6	650	ST	Coal
W A Parish 7	560	ST	Coal
W A Parish 8	595	ST	Coal
W A Parish GT 1	13	GT	Natural Gas
W B Tuttle 1	65	ST	Natural Gas
W B Tuttle 3	100	ST	Natural Gas
W B Tuttle 4	160	ST	Natural Gas
Whitney (TX)	30	Hydro	Hydro
WichitaFalls IPP 1a	39	CC	Natural Gas
WichitaFalls IPP 1b	39	CC	Natural Gas
Wise County 1a	350	CC	Natural Gas
Wise County 1b	350	CC	Natural Gas
Woodward Mountain I	7	WT	Wind
Woodward Mountain II	7	WT	Wind
Total Installed Capacity (MW)[9]	**70,824**		

[9] Wind capacity is counted at 8.7 percent of installed capacity.