KENTUCKY POWER COMPANY

2014 Analysis of System Losses

March 2016

Prepared by:

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March 15, 2016

Mr. David M. Roush
Director Regulatory Pricing & Analysis
American Electric Power
1 Riverside Plaza
Columbus, OH 43215

Mr. Chad Burnett
Director Economic Forecasting
American Electric Power
212 East 6th Street
Tulsa, OK 74119

RE: 2014 LOSS ANALYSIS

Dear Messrs. Roush and Burnett:

Transmitted herewith are the results of the 2014 Analysis of System Losses for the Kentucky Power Company's (KPCO) power system. Our analysis develops cumulative expansion factors (loss factors) for both demand (peak/kW) and energy (average/kWh) losses by discrete voltage levels applicable to metered sales data. Our analysis considers only technical losses in arriving at our final recommendations.

On behalf of MAC, we appreciate the opportunity to assist you in performing the loss analysis contained herein. The level of detailed load research and sales data by voltage level, coupled with a summary of power flow data and power system model, forms the foundation for determining reasonable and representative power losses on the KPCO system. Our review of these data and calculated loss results support the proposed loss factors as presented herein for your use in various cost of service, rate studies, and demand analyses.

Should you require any additional information, please let us know at your earliest convenience.

Sincerely,

Paul M. Normand

Paul M. Normand
Principal

Enclosure
PMN/rjp

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1.0 EXECUTIVE SUMMARY

This report presents Kentucky Power Company's (KPCO) 2014 Analysis of System Losses for the power systems as performed by Management Applications Consulting, Inc. (MAC). The study developed separate demand (kW) and energy (kWh) loss factors for each voltage level of service in the power system for KPCO. The cumulative loss factor results by voltage level, as presented herein, can be used to adjust metered kW and kWh sales data for losses in performing cost of service studies, determining voltage discounts, and other analyses which may require a loss adjustment.

The procedures used in the overall loss study were similar to prior studies and emphasized the use of "in house" resources where possible. To this end, extensive use was made of the Company's peak hour power flow data and transformer plant investments in the model. In addition, measured and estimated load data provided a means of calculating reasonable estimates of losses by using a "top-down" and "bottom-up" procedure. In the "top-down" approach, losses from the high voltage system, through and including distribution substations, were calculated along with power flow data, conductor and transformer loss estimates, and metered sales.

At this point in the analysis, system loads and losses at the input into the distribution substation system are known with reasonable accuracy. However, it is the remaining loads and losses on the distribution substations, primary system, secondary circuits, and services which are generally difficult to estimate. Estimated and actual Company load data provided the starting point for performing a "bottom-up" approach for calculating the remaining distribution losses. Basically, this "bottom-up" approach develops line loadings by first determining loads and losses at each level beginning at a customer's meter service entrance and then going through secondary lines, line transformers, primary lines and finally distribution substation. These distribution system loads and associated losses are then compared to the initial calculated input into Distribution Substation loadings for reasonableness prior to finalizing the loss factors. An overview of the loss study is shown on Figure 1.

With the emergence of transmission as a stand-alone function throughout various regions of the country, a modification to the historical calculation of the transmission loss factors was required. Historic loss studies recognized the multipath approach to losses from high voltage to low voltage delivery. The current definition of transmission losses recognized in the industry is simply to sum all losses at transmission as an integrated system. This approach will typically increase the resulting composite transmission loss factors but better reflects the topology of the systems with dispersed supply resources and interconnections.

The load research data provided the starting point for performing a "bottom-up" approach for estimating the remaining distribution losses. Basically, this "bottom-up" approach develops line loadings by first determining loads and losses at each level beginning at a customer's meter and service entrance and then going through secondary lines, line transformers, primary lines and finally distribution substation. These distribution system loads and associated losses are then compared to the initial calculated input into Distribution Substation loadings for reasonableness prior to finalizing the loss factors. An overview of the loss study is shown on Figure 1 on the next page.

Table 1, below, provides the final results from Appendix A for the 2014 calendar year. Exhibits 8 and 9 of Appendix A present a more detailed analysis of the final calculated summary results of losses by voltage segments and delivery service level in the Company's power system. These Table 1 cumulative loss expansion factors are applicable only to metered sales at the point of receipt for adjustment to the power system's input level.

TABLE 1
Loss Factors at Sales Level, Calendar Year 2014

Voltage Level of Service	Total Company	Distribution Only
Demand (kW)		
Transmission[1]	1.04534	–
Subtransmission	1.06960	1.02321
Primary Lines	1.08856	1.04135
Secondary	1.12391	1.07516
Energy (kWh)		
Transmission[1]	1.02972	–
Subtransmission	1.04424	1.01410
Primary Lines	1.05837	1.02782
Secondary	1.08595	1.05460
Losses – Net System Input[2]	6.27%MWh	
	9.87%MW	
Losses – Net System Output[3]	6.69%MWh	
	10.95%MW	

Composite Loss Factors at Metered Sales Level

	MW	MWH
Retail	1.11028	1.05306
Wholesale	1.06735	1.03357

The loss factors presented in the Delivery Only column of Table 1 are the Total KPCO loss factors divided by the transmission loss factor in order to remove these losses from each service level loss factor. For example, the secondary distribution demand loss factor of 1.07516 includes

[1] Reflects results for 765 kV, 345 kV 161 kV, and 138 kV.
[2] Net system input equals firm sales plus losses, Company use less non-requirement sales and related losses. See Appendix A, Exhibit 1, for their calculations.
[3] Net system output uses losses divided by output or sales data as a reference.

the recovery of all distribution only losses from the distribution substation, primary lines, line transformers, secondary conductors and services.

The net system input shown in Table 1 represents the MWh losses of 6.27% for the total KPCO internal load using calculated losses divided by the associated input energy to the system. The 6.69% represents the same losses using system output instead of input as a reference. Similarly, the net system input reference shown in Table 1 for MW losses is 9.87%, and the MW loss referenced to output is 10.95%. These calculations are all based on the data and results shown on Exhibits 1, 7 and 9 of the study.

Due to the very nature of losses being primarily a function of equipment loading levels for a peak load hour, the loss factor derivations for any voltage level must consider both the load at that level plus the loads from lower voltages and their associated losses. As a result, cumulative losses on losses equates to additional load at higher levels along with future changes (+ or –) in loads throughout the power system. It is therefore important to recognize that losses are multiplicative in nature (future) and not additive (test year only) for all future years to ensure total recovery based on prospective fixed loss factors for each service voltage.

The derivation of the cumulative loss factors shown in Table 1 have been detailed for all electrical facilities in Exhibit 9, page 1 for demand and page 2 for energy. Beginning on line 1 of page 1 (demand) under the secondary column, metered sales are adjusted for service losses on lines 3 and 4. This new total load (with losses) becomes the load amount for the next higher facilities of secondary conductors and their loss calculations. This process is repeated for all the installed facilities until the secondary sales are at the input level (line 45). The final loss factor for all delivery voltages using this same process is shown on line 46 and Table 1 for demand. This procedure is repeated in Exhibit 9, page 2, for the energy loss factors.

The loss factor calculation is simply the input required (line 45) divided by the metered sales (line 43).

An overview of the loss study is shown on Figure 1 on the next page. Figure 2 simply illustrates the major components that must be considered in a loss analysis.

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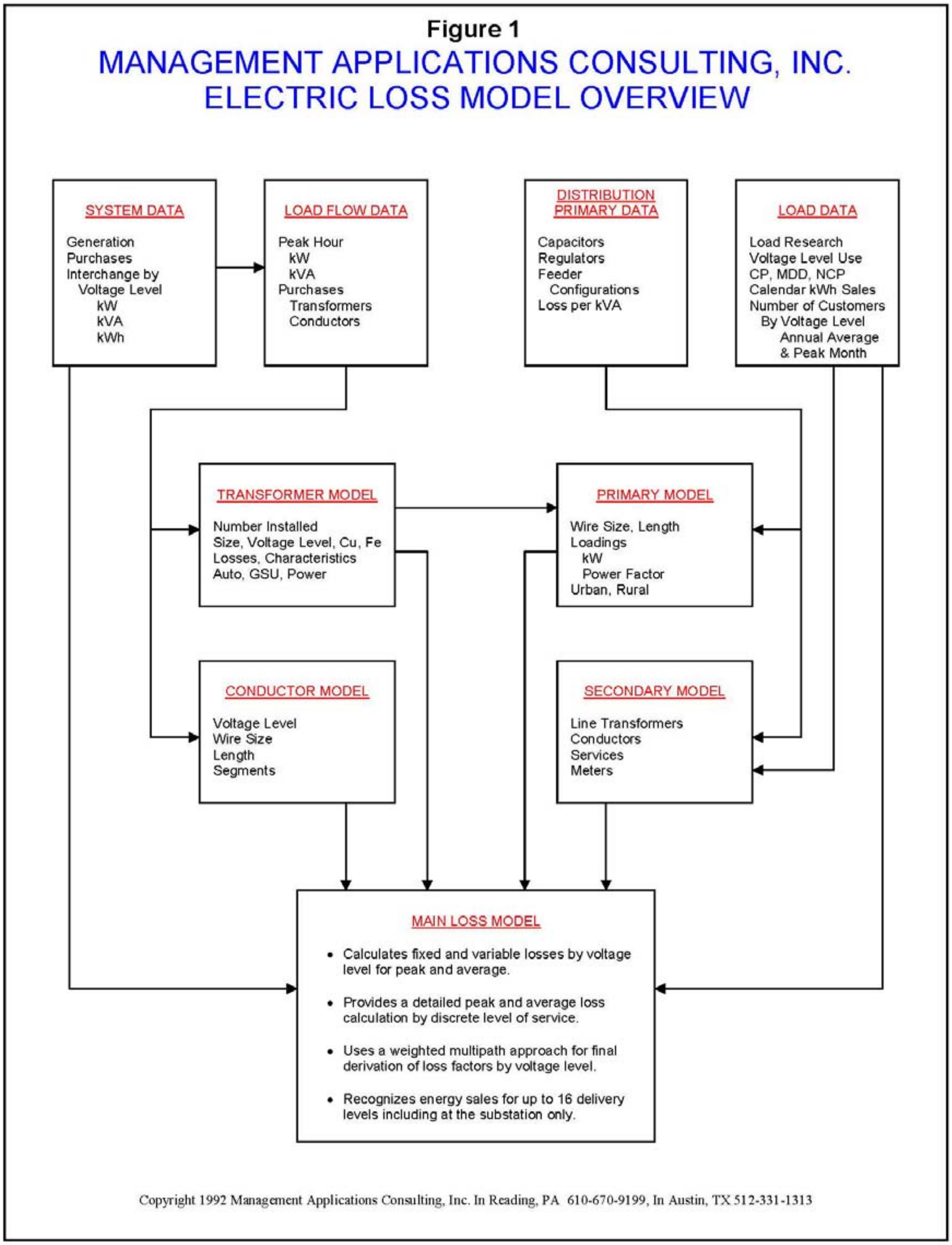

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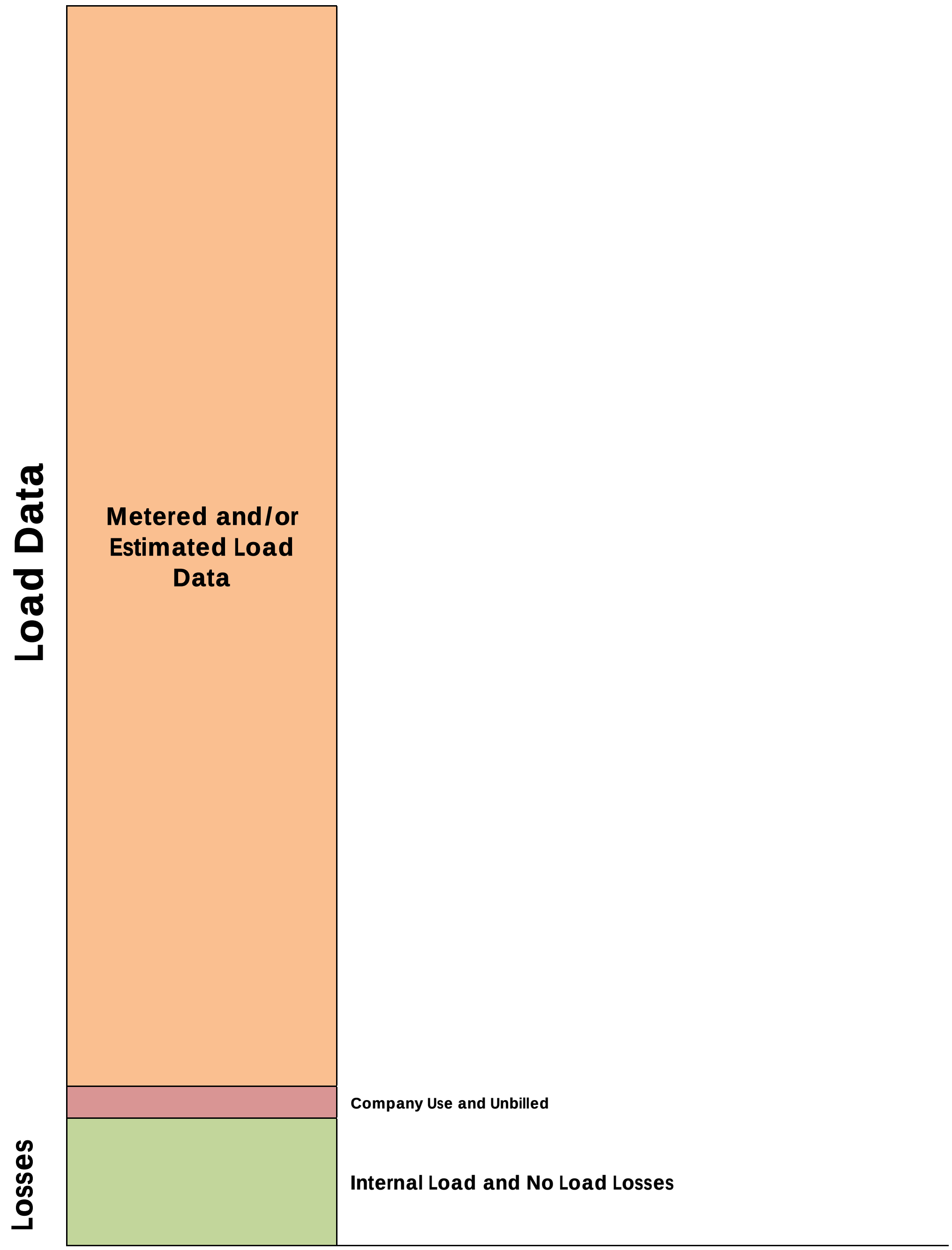
Figure 2
Generic Energy Loss Components



2.0 INTRODUCTION

This report of the 2014 Analysis of System Losses for the Company provides a summary of results, conceptual background or methodology, description of the analyses, and input information related to the study.

2.1 Conduct of Study

Typically, between five to ten percent of the total peak hour MW and annual MWH requirements of an electric utility is lost or unaccounted for in the delivery of power to customers. Investments must be made in facilities which support the total load which includes losses or unaccounted for load. Revenue requirements associated with load losses are an important concern to utilities and regulators in that customers must equitably share in all of these cost responsibilities. Loss expansion factors by voltage level are the mechanism by which customers' metered demand and energy data are mathematically adjusted to the generation or input level (point of reference) when performing cost and revenue calculations.

An acceptable accounting of losses can be determined for any given time period using available engineering, system, and customer data along with empirical relationships. This loss analysis for the delivery of demand and energy utilizes such an approach. A microcomputer loss model[4] is utilized as the vehicle to organize the available data, develop the relationships, calculate the losses, and provide an efficient and timely avenue for future updates and sensitivity analyses. Our procedures and calculations are similar with prior loss studies, and they rely on numerous databases that include customer statistics and power system investments at various voltage levels of service.

Company personnel performed most of the data gathering and data processing efforts and checked for reasonableness. MAC provided assistance as necessary to construct databases, transfer files, perform calculations, and check the reasonableness of results. Efforts in determining the data required to perform the loss analysis centered on information which was available from existing studies or reports within the Company. From an overall perspective, our efforts concentrated on five major areas:

1. System information concerning peak demand and annual energy requirements by voltage level,
2. High voltage power system power flow data and associated loss calculations,
3. Distribution system primary and secondary loss calculations,
4. Derivation of fixed and variable losses by voltage level, and
5. Development of final cumulative expansion factors at each voltage for peak demand (kW) and annual energy (kWh) requirements at the point of delivery (meter).

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2.2 Electric Power Losses

Losses in power systems consist of primarily technical losses with a much smaller level of non-technical losses.

Technical Losses

Electrical losses result from the transmission of energy over various electrical equipment. The largest component of total losses during peaking conditions is power dissipation as a result of varying loading conditions and are oftentimes called load losses which are mostly related to the square of the current (I^2R). These peak hour losses can be as high as 60-75% of all technical losses during peak loading conditions. The remaining losses are called no-load and represent essentially fixed (constant) energy losses throughout the year. These no-load losses represent energy required to energize various electrical equipment regardless of their loading levels over the entire year. The major portion of these no-load losses consists of core or magnetizing energy related to installed transformers throughout the power system and generates the major component of annual losses on any distribution system.

The following Table 2 summarizes the unadjusted fixed and variable losses by major functional categories from Exhibit 5 of Appendix A:

TABLE 2

	DEMAND (PEAK HOUR)			ENERGY (ANNUAL AVERAGE)		
	FIXED	VARIABLE	TOTAL	FIXED	VARIABLE	TOTAL
TRANS	4.32	57.28	61.60	37,857	169,715	207,572
(%)	7.02%	92.98%	100.00%	18.24%	81.76%	100.00%
SUBTRANS	1.24	25.28	26.53	10,885	74,913	85,799
(%)	4.68%	95.32%	100.00%	12.69%	87.31%	100.00%
DIST SUBS	2.22	3.99	6.20	19,419	6,455	25,874
(%)	35.73%	64.27%	100.00%	75.05%	24.95%	100.00%
PRIMARY	0.00	24.10	24.10	0	38,842	38,842
(%)	0.00%	100.00%	100.00%	0.00%	100.00%	100.00%
SECONDARY	10.82	20.25	31.08	94,793	30,866	125,659
(%)	34.82%	65.18%	100.00%	75.44%	24.56%	100.00%
TOTAL SYS.	18.60	130.90	149.50	162,954	320,791	483,745
(%)	12.44%	87.56%	100.00%	33.69%	66.31%	100.00%
TOTAL DIST	13.04	48.34	61.38	114,212	76,163	190,375
(%)	21.24%	78.76%	100.00%	59.99%	40.01%	100.00%

Non-Technical Losses

These are unaccounted for energy losses that are related to energy theft, metering, non-payment by customers, and accounting errors. Losses related to these areas are generally very small and can be extremely difficult and subjective to quantify. Our efforts generally do not develop any meaningful level because we assume that improving technology and utility practices have minimized these amounts.

2.3 Loss Impacts from Distributed Generation (DG)

The impacts of losses on a power system from the installation of various DG facilities will depend somewhat on the penetration level, type of installations and location on a circuit. Based on the results presented in Table 2 of this loss study, the impacts are significantly different from looking at any single peak load hour versus the potential impacts over all hours of an entire year. Use of a typical uniform loss factor(s) for each voltage level may require additional consideration to recognize that a reduced consumption level could have little or no impact due to the recovery requirements for the high level of fixed losses over the entire hourly electric grid condition for any DG location.

2.4 Description of Model

The loss model is a customized applications model, constructed using the Excel software program. Documentation consists primarily of the model equations at each cell location. A significant advantage of such a model is that the actual formulas and their corresponding computed values at each cell of the model are immediately available to the analyst.

A brief description of the three (3) major categories of effort for the preparation of each loss model is as follows:

- Main sheet which contains calculations for all primary and secondary losses, summaries of all conductor and transformer calculations from other sheets discussed below, output reports and supporting results.

- Transformer sheet which contains data input and loss calculations for each distribution substation and high voltage transformer. Separate iron and winding losses are calculated for each transformer by identified type.

- Conductor sheet containing summary data by major voltage level as to circuit miles, loading assumptions, and kW and kWh loss calculations. Separate loss calculations for each line segment were made using the Company's power flow data by line segment and summarized by voltage level in this model.

3.0 METHODOLOGY

3.1 Background

The objective of a Loss Study is to provide a reasonable set of energy (average) and demand (peak) loss expansion factors which account for system losses associated with the transmission and delivery of power to each voltage level over a designated period of time. The focus of this study is to identify the difference between total energy inputs and the associated sales with the difference being equitably allocated to all delivery levels. Several key elements are important in establishing the methodology for calculating and reporting the Company's losses. These elements are:

- Selection of voltage level of services,
- Recognition of losses associated with conductors, transformations, and other electrical equipment/components within voltage levels,
- Identification of customers and loads at various voltage levels of service,
- Review of generation or net power supply input at each level for the test period studied, and
- Analysis of kW and kWh sales by voltage levels within the test period.

The three major areas of data gathering and calculations in the loss analysis were as follows:

1. System Information (monthly and annual)
    - MWH generation and MWH sales.
    - Coincident peak estimates and net power supply input from all sources and voltage levels.
    - Customer load data estimates from available load research information, adjusted MWH sales, and number of customers in the customer groupings and voltage levels identified in the model.
    - System default values, such as power factor, loading factors, and load factors by voltage level.

2. High Voltage System

   - Conductor information was summarized from a database by the Company which reflects the transmission system by voltage level. Extensive use was made of the Company's power flow data with the losses calculated and incorporated into the final loss calculations.

   - Transformer information was developed in a database to model transformation at each voltage level. Substation power, step-up, and auto transformers were individually identified along with any operating data related to loads and losses.

   - Power flow data of peak condition was the primary source of equipment loadings and derivation of load losses in the high voltage loss calculations.

3. Distribution System

   - Distribution Substations – Data was developed for modeling each substation as to its size and loading. Loss calculations were performed from this data to determine load and no load losses separately for each transformer.

   - Primary lines – Line loading and loss characteristics for several representative primary circuits were obtained from the Company. These loss results developed kW loss per MW of load and a composite average was calculated to derive the primary loss estimate.

   - Line transformers – Losses in line transformers were based on each customer service group's size, as well as the number of customers per transformer. Accounting and load data provided the foundation with which to model the transformer loadings and to calculate load and no load losses.

   - Secondary network – Typical secondary networks were estimated for conductor sizes, lengths, loadings, and customer penetration for residential and small general service customers.

   - Services – Typical services were estimated for each secondary service class of customers identified in the study with respect to type, length, and loading.

The loss analysis was thus performed by constructing the model in segments and subsequently calculating the composite until the constraints of peak demand and energy were met:

- Information as to the physical characteristics and loading of each transformer and conductor segment was modeled.

- Conductors, transformers, and distribution were grouped by voltage level, and unadjusted losses were calculated.

- The loss factors calculated at each voltage level were determined by "compounding" the per-unit losses. Equivalent sales at the supply point were obtained by dividing sales at a specific level by the compounded loss factor to determine losses by voltage level.

- The resulting demand and energy loss expansion factors were then used to adjust all sales to the generation or input level in order to estimate the difference.

- Reconciliation of kW and kWh sales by voltage level using the reported system kW and kWh was accomplished by adjusting the initial loss factor estimates until the mismatch or difference was eliminated.

3.2 Calculations and Analysis

This section provides a discussion of the input data, assumptions, and calculations performed in the loss analysis. Specific appendices have been included in order to provide documentation of the input data utilized in the model.

3.2.1 Bulk, Transmission and Subtransmission Lines

The transmission and subtransmission line losses were calculated based on a modeling of unique voltage levels identified by the Company's power flow data and configuration for the entire integrated KPCO Power System. Specific information as to length of line, type of conductor, voltage level, peak load, maximum load, etc., were provided based on Company records and utilized as data input in the loss model.

Actual MW and MVA line loadings were based on KPCO's peak loading conditions. Calculations of line losses were performed for each line segment separately and combined by voltage levels for reporting purposes as shown in the Discussion of Results (Section 4.0) of this report. The loss calculations consisted of determining a circuit current value based on MVA line loadings and evaluating the I^2R results for each line segment.

After system coincident peak hour losses were identified for each voltage level, a separate calculation was then made to develop annual average energy losses based on a loss factor approach. Load factors were determined for each voltage level based on system and customer load information. An estimate of the Hoebel coefficient (see Appendix B) was then used to calculate energy losses for the entire period being analyzed. The results are presented in Section 4.0 of this report.

3.2.2 Transformers

The transformer loss analysis required several steps in order to properly consider the characteristics associated with various transformer types; such as, step-up, auto transformers, distribution substations, and line transformers. In addition, further efforts were required to identify both iron and winding losses within each of these transformer types in order to obtain reasonable peak (kW) and average energy (kWh) losses. While iron losses were considered essentially constant for each hour, recognition had to be made for the varying degree of winding losses due to hourly equipment loadings.

Standardized test data tables were used to represent no load information (fixed) and full load (variable) losses for different types and sizes of transformers. This test data was incorporated into the loss model to develop relationships representing winding and iron or core losses for the transformer loss calculation. These results were then totaled by various groups, as identified and discussed in Section 4.0.

The remaining miscellaneous losses considered in the loss study consisted of several areas which do not lend themselves to any reasonable level of modeling for estimating their respective losses and were therefore lumped together into a single loss factor. The typical range of values for these losses is from 0.10% to 0.25%, and we have assumed 0.0% value for this study. The losses associated with this loss factor include bus bars, unmetered station use, grounding transformers, cooling fans, heating and air conditioning requirements, and other remaining station use requirements.

3.2.3 Distribution System

The load data at the substation and customer level, coupled with primary and secondary network information, was sufficient to model the distribution system in adequate detail to calculate losses.

Primary Lines

Primary line loadings take into consideration the available distribution load along with the actual customer loads including losses. Primary line loss estimates were prepared by the Company for use in this loss study. These estimates considered loads per substation, voltage levels, loadings, total circuit miles, wire size, and single- to three-phase investment estimates. All of these factors were considered in calculating the actual demand (kW) and energy (kWh) for the primary system.

Line Transformers

Losses in line transformers were determined based on typical transformer sizes for each secondary customer service group and an estimated or calculated number of customers per transformer. Accounting records and estimates of load data provided the necessary database with which to model the loadings. These calculations also made it possible to determine separate winding and iron losses for distribution line transformers, based on a table of representative losses for various transformer sizes.

Secondary Line Circuits

A calculation of secondary line circuit losses was performed for loads served through these secondary line investments. Estimates of typical conductor sizes, lengths, loadings and customer class penetrations were made to obtain total circuit miles and losses for the secondary network. Customer loads which do not have secondary line requirements were also identified so that a reasonable estimate of losses and circuit miles of these investments could be made.

Service Drops and Meters

Service drops were estimated for each secondary customer reflecting conductor size, length and loadings to obtain demand losses. A separate calculation was also performed using customer maximum demands to obtain kWh losses. Meter loss estimates were also made for each customer and incorporated into the calculations of kW and kWh losses included in the Summary Results.

4.0 DISCUSSION OF RESULTS

A brief description of each Exhibit provided in Appendix A follows:

Exhibit 1 - Summary of Company Data

This exhibit reflects system information used to determine percent losses and a detailed summary of kW and kWh losses by voltage level. The loss factors developed in Exhibit 7 are also summarized by voltage level.

Exhibit 2 - Summary of Conductor Information

A summary of MW and MWH load and no load losses for conductors by voltage levels is presented. The sum of all calculated losses by voltage level is based on input data information provided in Appendix A. Percent losses are based on equipment loadings.

Exhibit 3 - Summary of Transformer Information

This exhibit summarizes transformer losses by various types and voltage levels throughout the system. Load losses reflect the winding portion of transformer losses while iron losses reflect the no load or constant losses. MWH losses are estimated using a calculated loss factor for winding and the test year hours times no load losses.

Exhibit 4 - Summary of Losses Diagram (2 Pages)

This loss diagram represents the inputs and output of power at system peak conditions. Page 1 details information from all points of the power system and what is provided to the distribution system for primary loads. This portion of the summary can be viewed as a "top down" summary into the distribution system.

Page 2 represents a summary of the development of primary line loads and distribution substations based on a "bottom up" approach. Basically, loadings are developed from the customer meter through the Company's physical investments based on load research and other metered information by voltage level to arrive at MW and MVA requirements during peak load conditions by voltage levels.

Exhibit 5 - Summary of Sales and Calculated Losses

Summary of Calculated Losses represents a tabular summary of MW and MWH load and no load losses by discrete areas of delivery within each voltage level. Losses have been identified and are derived based on summaries obtained from Exhibits 2 and 3 and losses associated with meters, capacitors and regulators.

Exhibit 6 - Development of Loss Factors, Unadjusted

This exhibit calculates demand and energy losses and loss factors by specific voltage levels based on sales level requirements. The actual results reflect loads by level and summary totals of losses at that level, or up to that level, based on the results as shown in Exhibit 5. Finally, the estimated values at generation are developed and compared to actual generation to obtain any difference or mismatch.

Exhibit 7 - Development of Loss Factors, Adjusted

The adjusted loss factors are the results of adjusting Exhibit 6 for any difference. All differences between estimated and actual are prorated to each level based on the ratio of each level's total load plus losses to the system total. These new loss factors reflect an adjustment in losses due only to the kW and kWh mismatch.

Exhibit 8 – Adjusted Losses and Loss Factors by Facility

These calculations present an expanded summary detail of Exhibit 7 for each segment of the power system with respect to the flow of power and associated losses from the receipt of energy at the meter to the generation for the KPCO power system.

Exhibit 9 – Summary of Losses by Delivery Voltage

These calculations present a reformatted summary of losses presented in Exhibits 7 and 8 by power system delivery segment as calculated by voltage level of service based on reported metered sales.

Appendix A

Results of 2014 KPCO Integrated Power System Loss Analysis

KENTUCKY POWER 2014 LOSS ANALYSIS

KENTUCKY POWER

EXHIBIT 1

SUMMARY OF COMPANY DATA

ANNUAL PEAK	1,645	MW
ANNUAL SYSTEM INPUT	7,091,765	MWH
ANNUAL SALES OUTPUT	6,647,278	MWH
SYSTEM LOSSES @ INPUT	444,487	or 6.27%
SYSTEM LOSSES @ OUTPUT	444,487	or 6.69%
SYSTEM LOAD FACTOR	49.2%	

SUMMARY OF LOSSES - OUTPUT RESULTS

SERVICE	KV	--- MW ---	Input	% TOTAL	--- MWH ---	Input	% TOTAL
TRANS	765,345	65.4		40.31%	181,715		40.88%
	161,138		3.98%			2.56%	
SUBTRANS	69,46,34	28.2		17.36%	75,111		16.90%
			1.71%			1.06%	
PRIMARY	34,12,1	33.9		20.90%	63,793		14.35%
			2.06%			0.90%	
SECONDARY	120/240,to,477	34.8		21.43%	123,867		27.87%
			2.11%			1.75%	
TOTAL		162.3		100.00%	444,487		100.00%
			9.87%			6.27%	

SUMMARY OF LOSS FACTORS

SERVICE	KV	CUMMULATIVE SALES EXPANSION FACTORS DEMAND (Peak) d	1/d	ENERGY (Annual) e	1/e
TOT TRANS	765,345 161,138	1.04534	0.95663	1.02972	0.97113
SUBTRAN	69,46,34	1.06960	0.93493	1.04424	0.95763
PRIMARY	34,12,1	1.08856	0.91864	1.05837	0.94485
SECONDARY	120/240,to,477	1.12391	0.88975	1.08595	0.92085

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SUMMARY OF CONDUCTOR INFORMATION

DESCRIPTION		CIRCUIT MILES	LOADING % RATING	----- MW LOSSES ----- LOAD	NO LOAD	TOTAL	---- MWH LOSSES ---- LOAD	NO LOAD	TOTAL
--- BULK -----------	765 KV OR GREATER								
TIE LINES		0.0	0.00%	0.000	0.000	0.000	0	0	0
BULK TRANS		262.2	0.00%	7.313	0.787	8.099	21,667	6,891	28,558
SUBTOT		262.2		7.313	0.787	8.099	21,667	6,891	28,558
--- TRANS ---------	138 KV TO 765.00 KV								
TIE LINES		0	0.00%	0.000	0.000	0.000	0	0	0
TRANS1	161 KV	55.8	0.00%	3.325	0.837	4.162	9,851	7,332	17,183
TRANS2	138 KV	358.5	0.00%	43.936	0.180	44.116	130,182	1,575	131,757
SUBTOT		414.3		47.261	1.017	48.278	140,033	8,908	148,940
--- SUBTRANS ------	35 KV TO 138 KV								
TIE LINES		0	0.00%	0.000	0.000	0.000	0	0	0
SUBTRANS1	69 KV	428.5	0.00%	20.101	0.000	20.101	59,558	0	59,558
SUBTRANS2	46 KV	166.1	0.00%	3.662	0.000	3.662	10,851	0	10,851
SUBTRANS3	35 KV	2.6	0.00%	0.016	0.005	0.021	47	40	87
SUBTOT		597.2		23.779	0.005	23.784	70,457	40	70,497
PRIMARY LINES		8,160		24.050	0.000	24.050	38,764	0	38,764
SECONDARY LINES		2,476		7.015	0.000	7.015	10,516	0	10,516
SERVICES		3,108		7.687	0.360	8.047	12,749	3,153	15,903
TOTAL		15,017		117.104	2.168	119.272	294,187	18,991	313,178

KENTUCKY POWER 2014 LOSS ANALYSIS

EXHIBIT 3

SUMMARY OF TRANSFORMER INFORMATION

DESCRIPTION		KV CAPACITY VOLTAGE	MVA	NUMBER TRANSFMR	AVERAGE SIZE	LOADING %	MVA LOAD	--------- MW LOSSES -------- LOAD	NO LOAD	TOTAL	------- MWH LOSSES ------ LOAD	NO LOAD	TOTAL
BULK STEP-UP		765	1,500.0	3	500.0	7.63%	114	0.020	0.662	0.682	59	5,795	5,854
BULK - BULK			0.0	0	0.0	0.00%	0	0	0.000	0.000	0	0	0
BULK - TRANS1		161	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
BULK - TRANS2		138	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
TRANS1 STEP-UP		161	1,000.0	5	200.0	80.61%	806	1.265	0.830	2.095	3,748	7,266	11,015
TRANS1 - TRANS2		138	735.0	4	183.8	56.23%	413	0.311	0.606	0.917	921	5,313	6,234
TRANS1-SUBTRANS1		69	54.0	1	54.0	111.87%	60	0.117	0.056	0.173	347	487	834
TRANS1-SUBTRANS2		46	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
TRANS1-SUBTRANS3		35	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
TRANS2 STEP-UP		138	408.0	4	102.0	80.58%	329	1.109	0.421	1.530	3,286	3,685	6,971
TRANS2-SUBTRANS1		69	1,016.0	15	67.7	74.92%	761	1.020	1.040	2.060	3,022	9,106	12,129
TRANS2-SUBTRANS2		46	75.0	2	37.5	99.32%	74	0.298	0.081	0.379	883	708	1,591
TRANS2-SUBTRANS3		35	45.0	1	45.0	54.65%	25	0.065	0.046	0.111	193	406	599
SUBTRAN1 STEP-UP		69	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN2 STEP-UP		46	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN3 STEP-UP		35	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN1-SUBTRAN2		46	12.0	1	12.0	9.35%	1	0.004	0.016	0.020	12	138	150
SUBTRAN1-SUBTRAN3		35	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN2-SUBTRAN3		35	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
							DISTRIBUTION SUBSTATIONS						
TRANS1 -	161	33	28.2	2	14.1	53.72%	15	0.037	0.037	0.074	59	324	383
TRANS1 -	161	12	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
TRANS1 -	161	1	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
TRANS2 -	138	33	390.0	12	32.5	58.79%	229	0.596	0.439	1.035	965	3,843	4,808
TRANS2 -	138	12	80.0	4	20.0	63.10%	50	0.138	0.096	0.234	223	841	1,064
TRANS2 -	138	1	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN1-	69	33	281.0	13	21.6	74.80%	210	0.630	0.333	0.963	1,020	2,919	3,939
SUBTRAN1-	69	12	754.8	53	14.2	72.44%	547	1.974	0.963	2.937	3,196	8,436	11,632
SUBTRAN1-	69	1	15.0	2	7.5	12.91%	2	0.002	0.024	0.026	3	209	212
SUBTRAN2-	46	33	105.0	4	26.3	77.61%	81	0.235	0.122	0.356	380	1,067	1,447
SUBTRAN2-	46	12	143.1	12	11.9	66.00%	94	0.325	0.193	0.518	526	1,692	2,218
SUBTRAN2-	46	1	0.7	1	0.7	36.95%	0	0.001	0.001	0.002	1	13	14
SUBTRAN3-	35	33	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
SUBTRAN3-	35	12	5.0	1	5.0	126.22%	6	0.050	0.009	0.058	80	77	157
SUBTRAN3-	35	1	0.0	0	0.0	0.00%	0	0.000	0.000	0.000	0	0	0
PRIMARY - PRIMARY			23.8	4	5.9	55.99%	13	0.048	0.039	0.087	77	341	418
LINE TRANSFRMR			3,275.3	100,027	32.7	37.42%	1,225	5.553	10.461	16.014	7,600	91,639	99,239
			===========	===========	===========	===========		===========	===========	===========	===========	==========	===========
TOTAL			9,947	100,171				13.797	16.473	30.270	26,604	144,304	170,907

KENTUCKY POWER 2014 LOSS ANALYSIS

SUMMARY OF LOSSES DIAGRAM - DEMAND MODEL - SYSTEM PEAK 1645 MW

BULK TIE LINES		
LOAD	0.00%	MW
LOAD LOSS	0.000	MW
NOLD LOSS	0.000	MW

BULK LINES		
LOADING	0.00%	
LOAD LOSS	7.313	MW
NOLD LOSS	0.787	MW

BULK STEP UP		
LOADING	7.63%	
NO LOAD	0.662	MW
LOAD	0.020	MW
AVG SIZE	500	MVA
NUMBER	3	

BULK-BULK		
LOADING	0.00%	
NO LOAD	0	MW
LOAD	0	MW
AVG SIZE	0	MVA
NUMBER	0	

TRANS TIE LINES		
LOAD	0.00%	MW
LOAD LOSS	0.000	MW
NOLD LOSS	0.000	MW

BULK-TRANS1 STEP DOWN		
LOADING	0.00%	
NO LOAD	0.000	MW
LOAD	0.000	MW
AVG SIZE	0	MVA
NUMBER	0	

TRAN1-TRAN2 STEP DOWN		
LOADING	56.23%	
NO LOAD	0.606	MW
LOAD	0.311	MW
AVG SIZE	183.75	MVA
NUMBER	4	

BULK-TRANS2 STEP DOWN		
LOADING	0.00%	
NO LOAD	0.000	MW
LOAD	0.000	MW
AVG SIZE	0	MVA
NUMBER	0	

TRANS 1&2 STEP UPS		
LDNG TR1SU	80.61%	
NOLOAD1&2	1.250	MW
LOAD 1&2	2.374	MW
AVSIZ TR1SU	200.0	MVA
NUMBER	5	

TRANS1	161.0	KV
LOADING	0.00%	
LOAD LOSS	3.325	MW
NOLD LOSS	0.837	MW

TRANS2	138.0	KV
LOADING	0.00%	
LOAD LOSS	43.936	MW
NOLD LOSS	0.180	MW

TRANS CUST		
SUBS	0.000	MW
	0.000	MVA
LINES		MW
		MVA

SUBTRANS TIE LINES		
LOAD	0.00%	MW
LOAD LOSS	0.000	MW
NOLD LOSS	0.000	MW

TRANS1&2-SUBTRANS1		
LDNG TR2-ST	74.92%	
NO LOAD	1.095	MW
LOAD	1.137	MW
AVSIZ TR2	67.73333333	MVA
NUMBER	16	

SUBTR1&2-SUBTRANS2&3		
LOADING	0.00%	
NO LOAD	0.016	MW
LOAD	0.004	MW
AVG SIZE	0	MVA
NUMBER	1	

TRANS1&2- SUBTRANS2		
LDNG TR2-ST	99.32%	
NO LOAD	0.081	MW
LOAD	0.298	MW
AVSIZ TR2-ST	37.50	MVA
NUMBER	2	

TRANS1&2-SUBTRANS3	
LDNG TR2-ST2	54.65%
NO LOAD	0.05
LOAD	0.07
AVSIZ TR2-ST2	45.00
NUMBER	1

SUBTRANS1,2,&3 STEP UPS		
LDNG ST1SU	0.00%	
NO LOAD	0.000	MW
LOAD	0.000	MW
AVSIZ ST2	0.0	MVA
NUMBER	0	

SUBTRANS1	69	KV
LOADING	0.00%	
LOAD LOSS	20.101	MW
NOLD LOSS	0.000	MW

SUBTRANS2	46	KV
LOADING	0.00%	
LOAD LOSS	3.662	MW
NOLD LOSS	0.000	MW

SUBTRANS2	35	KV
LOADING	0.00%	
LOAD LOSS	0.016	MW
NOLD LOSS	0.005	MW

SUBTRANS CUST	
SUBS - MW	0.000
MVA	0.000
LINES- MW	
MVA	

TO DISTRIBUTION SYSTEM

TOTAL 1236.2 MVA 1211.5 MW

TRANS1	15.1 MVA	1.23%	161 KV
TRANS2	279.8 MVA	22.63%	138 KV
SUBTRANS1	758.9 MVA	61.38%	69 KV
SUBTRANS2	176.2 MVA	14.25%	46 KV
SUBTRANS3	6.3 MVA	0.51%	35 KV

KENTUCKY POWER 2014 LOSS ANALYSIS

FROM HIGH VOLTAGE SYSTEM

TOTAL 1,236 MVA 1,212 MW

TRANS1	TRANS2	SUBTRANS1	SUBTRANS2	SUBTRANS3
15.1 MVA	279.8 MVA	758.9 MVA	176.2 MVA	6.3 MVA
1.23%	22.63%	61.38%	14.25%	0.51%
161 KV	138 KV	69 KV	46 KV	35 KV

DISTRIBUTION SYSTEM LOAD

	PRIM1	PRIM2	PRIM3	PRIM1	PRIM2	PRIM3	PRIM1	PRIM2	PRIM3	PRIM1	PRIM2	PRIM3	PRIM1	PRIM2	PRIM3
VOLTAGE	33	12	1	33	12	1	33	12	1	33	12	1	33	12	1
LOAD MVA	15	0	0	229	50	0	210	547	2	81	94	0	0	6	0
% SYS TOT	1.23%	0.00%	0.00%	18.55%	4.08%	0.00%	17.00%	44.23%	0.16%	6.59%	7.64%	0.02%	0.00%	0.51%	0.00%
NOLD LOSS	0.037	0.000	0.000	0.439	0.096	0.000	0.333	0.963	0.024	0.122	0.193	0.001	0.000	0.009	0.000
LOAD LOSS	0.037	0.000	0.000	0.596	0.138	0.000	0.630	1.974	0.002	0.235	0.325	0.001	0.000	0.050	0.000
AVG SIZE	14.1	0.0	0.0	32.5	20.0	0.0	21.6	14.2	7.5	26.3	11.9	0.7	0.0	5.0	0.0
NUMBER	2	0	0	12	4	0	13	53	2	4	12	1	0	1	0
DIVERSITY RATIO	1.000	0.000	0.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000

PRIMARY LINES

LOADING	1204.923	MW
@ SYS PF	1229.513	MVA
LOAD LOSS	24.050	MW
NOLD LOSS	0.000	MW
TOT LOSS	24.050	MW

PRIM/PRIM TRANSF

LOADING	13.297	MW
NOLD LOSS	0.039	MW
LOAD LOSS	0.048	MW
AVG SIZE	5.94	
NUMBER	4	

PRIM CUST LOADS

NO LINES	0.000	MW
CUST SUB	0.000	MVA
NO LINES	0.000	MW
CO. SUB	0.000	MVA
PRIM WITH	60.000	MW
LINES	65.217	MVA

LINE TRANSFORMERS

LOADING	1120.786	MW	MVA	1241.505
NOLD LOSS	10.461	MW		
LOAD LOSS	5.553	MW		
AVG SIZE	32.7	KVA		
NUMBER	100027			

SECONDARY LINES

LOAD	476.505	MW
LOAD LOSS	7.015	MW
NOLD LOSS	0.000	MW
TOT LOSS	7.015	MW

NO SECONDARY LINES

LOAD 628.267 MW

SERVICES

LOAD	1097.757	MW
LOAD LOSS	7.687	MW
NOLD LOSS	0.360	MW
TOT LOSS	8.047	MW

CUSTOMER SECONDARY LOAD

1089.710 MW

KENTUCKY POWER 2014 LOSS ANALYSIS

SUMMARY of SALES and CALCULATED LOSSES

LOSS # AND LEVEL	MW LOAD	NO LOAD +	LOAD =	TOT LOSS	EXP FACTOR	CUM EXP FAC	MWH LOAD	NO LOAD +	LOAD =	TOT LOSS	EXP FACTOR	CUM EXP FAC
1 BULK XFMMR	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0	0
2 BULK LINES	112.1	1.45	7.33	8.78	1.084986	1.084986	549,918	12,685	21,726	34,412	1.0667532	1.0667532
3 TRANS1 XFMR	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
4 TRANS1 LINES	790.0	1.67	4.59	6.26	1.007983	1.007983	3,875,424	14,599	13,599	28,198	1.0073294	1.0073294
5 TRANS2TR1 SD	405.0	0.61	0.31	0.92	1.002270	1.010271	1,986,768	5,313	921	6,234	1.0031476	1.0105001
6 TRANS2BLK SD	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
7 TRANS2 LINES	1,177.2	0.60	45.04	45.65	1.040339	1.044015	5,557,352	5,261	133,467	138,728	1.0256021	1.0294520
TOTAL TRAN	1,508.3	4.32	57.28	61.60	1.042580	1.042580	6,295,188	37,857	169,715	207,572	1.0340974	1.0340974
8 STR1BLK SD												
9 STR1T1 SD	59.2	0.06	0.12	0.17	1.002924	1.045629	290,412	487	347	834	1.0028797	1.0370753
10 SRT1T2 SD	746.0	1.04	1.02	2.06	1.002768	1.045466	3,659,578	9,106	3,022	12,129	1.0033252	1.0375359
11 SUBTRANS1 LINES	1,030.2	0.00	20.10	20.10	1.019900	1.063327	4,749,989	0	59,558	59,558	1.0126979	1.0472282
12 STR2T1 SD	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
13 STR2T2 SD	73.0	0.08	0.30	0.38	1.005217	1.048019	358,109	708	883	1,591	1.0044632	1.0387128
14 STR2S1 SD	1.1	0.02	0.00	0.02	1.018255	1.082737	5,396	138	12	150	1.0285059	1.0770804
15 SUBTRANS2 LINES	174.1	0.00	3.66	3.66	1.021487	1.064981	613,505	0	10,851	10,851	1.0180053	1.052717
16 STR3T1 SD	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
17 STR3T2 SD	24.1	0.05	0.07	0.11	1.004642	1.047419	118,225	406	193	599	1.0050892	1.0393600
18 STR3S1 SD	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
19 STR3S2 SD	0.0	0.00	0.00	0.00	0.000000	0.000000	0	0	0	0	0.0000000	0.0000000
20 SUBTRANS3 LINES	24.1	0.00	0.02	0.02	1.000854	1.043470	118,225	40	47	87	1.0007394	1.0348620
21 SUBTRANS TOTAL	1,242.0	1.24	25.28	26.53	1.021823	1.065332	5,402,000	10,885	74,913	85,799	1.0161391	1.050787
DISTRIBUTION SUBST												
TRANS1	14.8	0.04	0.04	0.07	1.004980	1.047771	52,147	324	59	383	1.0073969	1.0417465
TRANS2	274.2	0.53	0.73	1.27	1.004650	1.047428	963,053	4,684	1,189	5,873	1.0061356	1.0404422
SUBTR1	743.7	1.32	2.61	3.93	1.005307	1.068970	2,612,391	11,564	4,219	15,783	1.0060784	1.0535936
SUBTR2	172.6	0.32	0.56	0.88	1.005104	1.070418	606,435	2,771	907	3,678	1.0061023	1.0591406
SUBTR3	6.2	0.01	0.05	0.06	1.009524	1.053407	21,725	77	80	157	1.0072934	1.0424096
WEIGHTED AVERAGE	1,211.5	2.22	3.99	6.20	1.005147	1.063962	4,255,751	19,419	6,455	25,874	1.0061171	1.0512057
PRIMARY INTRCHNGE	0.0				0.000000		0				0.0000000	
PRIMARY LINES	1,204.9	0.00	24.10	24.10	1.020408	1.085676	4,226,976	0	38,842	38,842	1.0092742	1.0609548
LINE TRANSF	1,120.8	10.46	5.55	16.01	1.014495	1.101413	3,733,697	91,639	7,600	99,239	1.0273052	1.0899243
SECONDARY	1,104.8	0.00	7.01	7.01	1.006390	1.108451	3,634,457	0	10,516	10,516	1.0029020	1.0930872
SERVICES	1,097.8	0.36	7.69	8.05	1.007385	1.116637	3,623,941	3,153	12,749	15,903	1.0044076	1.0979051
		==========	==========	==========				==========	==========	==========		
TOTAL SYSTEM		18.60	130.90	149.50				162,954	320,791	483,745		

KENTUCKY POWER 2014 LOSS ANALYSIS

EXHIBIT 6

DEVELOPMENT of LOSS FACTORS
UNADJUSTED
DEMAND

LOSS FACTOR LEVEL	CUSTOMER SALES MW a	CALC LOSS TO LEVEL b	SALES MW @ GEN c	CUM PEAK EXPANSION FACTORS d	1/d
BULK LINES	0.0	0.0	0.0	0.00000	0.00000
TRANS SUBS	0.0	0.0	0.0	0.00000	0.00000
TRANS LINES	52.0	2.2	54.2	1.04258	0.95916
TOTAL TRANS	0.0	0.0	0.0	0.00000	0.00000
SUBTRANS	281.0	18.4	299.4	1.06533	0.93867
PRIM SUBS	0.0	0.0	0.0	0.00000	0.00000
PRIM LINES	60.0	5.1	65.1	1.08568	0.92109
SECONDARY	1,089.7	127.1	1,216.8	1.11664	0.89555
TOTALS	1,482.7	152.8	1,635.5		

DEVELOPMENT of LOSS FACTORS
UNADJUSTED
ENERGY

LOSS FACTOR LEVEL	CUSTOMER SALES MWH a	CALC LOSS TO LEVEL b	SALES MWH @ GEN c	CUM ANNUAL EXPANSION FACTORS d	1/d
BULK LINES	0	0	0	0.00000	0.00000
TRANS SUBS	0	0	0	0.00000	0.00000
TRANS LINES	447,838	15,270	463,108	1.03410	0.96703
TOTAL TRANS	0	0	0	0.00000	0.00000
SUBTRANS	2,136,964	108,529	2,245,493	1.05079	0.95167
PRIM SUBS	0	0	0	0.00000	0.00000
PRIM LINES	454,438	27,700	482,138	1.06095	0.94255
SECONDARY	3,608,038	353,245	3,961,283	1.09791	0.91083
TOTALS	6,647,278	504,745	7,152,023		

ESTIMATED VALUES AT GENERATION

LOSS FACTOR AT VOLTAGE LEVEL	MW	MWH
BULK LINES	0.00	0
TRANS SUBS	0.00	0
TRANS LINES	54.21	463,108
SUBTRANS SUBS	0.00	0
SUBTRANS LINES	299.36	2,245,493
PRIM SUBS	0.00	0
PRIM LINES	65.14	482,138
SECONDARY	1,216.81	3,961,283
SUBTOTAL	1,635.52	7,152,023
ACTUAL ENERGY	1,645.00	7,091,765
MISSMATCH	(9.48)	60,258
% MISSMATCH	-0.58%	0.85%

KENTUCKY POWER 2014 LOSS ANALYSIS

DEVELOPMENT of LOSS FACTORS
ADJUSTED
DEMAND

LOSS FACTOR LEVEL	CUSTOMER SALES MW a	SALES ADJUST b	CALC LOSS TO LEVEL c	SALES MW @ GEN d	CUM PEAK EXPANSION FACTORS e	f=1/e
BULK LINES	0.0	0.0	0.0	0.0	0.00000	0.00000
TRANS SUBS	0.0	0.0	0.0	0.0	0.00000	0.00000
TRANS LINES	52.0	0.0	2.4	54.4	1.04534	0.95663
TOTAL TRANS	0.0	0.0	0.0	0.0	0.00000	0.00000
SUBTRANS	281.0	0.0	19.6	300.6	1.06960	0.93493
PRIM SUBS	0.0	0.0	0.0	0.0	0.00000	0.00000
PRIM LINES	60.0	0.0	5.3	65.3	1.08856	0.91864
SECONDARY	1,089.7	0.0	135.0	1,224.7	1.12391	0.88975
			162.3			
TOTALS	1,482.7	0.0	162.3	1,645.0		

DEVELOPMENT of LOSS FACTORS
ADJUSTED
ENERGY

LOSS FACTOR LEVEL	CUSTOMER SALES MWH a	SALES ADJUST b	CALC LOSS TO LEVEL c	SALES MWH @ GEN d	CUM ANNUAL EXPANSION FACTORS e	f=1/e
BULK LINES	0	0	0	0	0.00000	0.00000
TRANS SUBS	0	0	0	0	0.00000	0.00000
TRANS LINES	447,838	0	13,311	461,149	1.02972	0.97113
TOTAL TRANS	0	0	0	0	0.00000	0.00000
SUBTRANS	2,136,964	0	94,546	2,231,510	1.04424	0.95763
PRIM SUBS	0	0	0	0	0.00000	0.00000
PRIM LINES	454,438	0	26,528	480,966	1.05837	0.94485
SECONDARY	3,608,038	0	310,103	3,918,141	1.08595	0.92085
			444,488			
TOTALS	6,647,278	0	444,487	7,091,766		

ESTIMATED VALUES AT GENERATION

LOSS FACTOR AT VOLTAGE LEVEL	MW	MWH
BULK LINES	0.00	0
TRANS SUBS	0.00	0
TRANS LINES	54.36	461,149
SUBTRANS SUBS	0.00	0
SUBTRANS LINES	300.56	2,231,510
PRIM SUBS	0.00	0
PRIM LINES	65.31	480,966
SECONDARY	1,224.74	3,918,141
	1,644.97	7,091,766
ACTUAL ENERGY	1,645.00	7,091,765
MISSMATCH	(0.03)	1
% MISSMATCH	0.00%	0.00%

Adjusted Losses and Loss Factors by Facility EXHIBIT 8

Unadjusted Losses by Segment

	MW	Unadjusted	MWH	Unadjusted
Service Drop Losses	8.05	8.48	15,903	17,657
Secondary Losses	7.01	7.39	10,516	11,677
Line Transformer Losses	16.01	16.88	99,239	110,186
Primary Line Losses	24.10	25.40	38,842	43,126
Distribution Substation Losses	6.20	6.54	25,874	28,729
Subtransmission Losses	26.53	26.53	85,799	85,799
Transmission System Losses	61.60	61.60	207,572	207,572
Total	149.50	152.81	483,745	504,745

Mismatch Allocation by Segment

	MW	MWH	Note adjusting
Service Drop Losses	-0.53	1,981	1,981
Secondary Losses	-0.46	1,310	1,310
Line Transformer Losses	-1.05	12,362	12,362
Primary Line Losses	-1.57	4,838	4,838
Distribution Substation Losses	-0.41	3,223	3,223
Subtransmission Losses	-1.64	10,688	10,688
Transmission System Losses	-3.82	25,856	25,856
Total	-9.48	60,258	60,258
			60,258

Adjusted Losses by Segment

	MW	% of Total	MWH	% of Total
Service Drop Losses	9.01	5.6%	15,676	3.5%
Secondary Losses	7.85	4.8%	10,367	2.3%
Line Transformer Losses	17.92	11.0%	97,825	22.0%
Primary Line Losses	26.97	16.6%	38,288	8.6%
Distribution Substation Losses	6.94	4.3%	25,506	5.7%
Subtransmission Losses	28.17	17.4%	75,111	16.9%
Transmission System Losses	65.42	40.3%	181,715	40.9%
Total	162.29	100.0%	444,487	100.0%

Loss Factors by Segment	**MW**	**MWH**
Retail Sales from Service Drops	1089.71	3,608,038
Adjusted Service Drop Losses	9.01	15,676
Input to Service Drops	1098.72	3,623,714
Service Drop Loss Factor	**1.00827**	**1.00434**
Output from Secondary	1098.72	3,623,714
Adjusted Secondary Losses	7.85	10,367
Input to Secondary	1106.57	3,634,081
Secondary Conductor Loss Factor	**1.00715**	**1.00286**
Output from Line Transformers	1106.57	3,634,081
Adjusted Line Transformer Losses	17.92	97,825
Input to Line Transformers	1124.49	3,731,905
Line Transformer Loss Factor	**1.01620**	**1.02692**
Secondary Composite	1.03192	1.03433
Retail Sales from Primary	60.00	454,438
Req. Whls Sales from Primary	0.00	0
Input to Line Transformers	1124.49	3,731,905
Output from Primary Lines	1184.49	4,186,343
Adjusted Primary Line Losses	26.97	38,288
Input to Primary Lines	1211.47	4,224,631
Primary Line Loss Factor	**1.02277**	**1.00915**
Out TO PR from Distribution Substations	1211.47	4,224,631
Req. Whls Sales from Substations	0.00	0
Retail Sales from Substations	0.00	0
TotalOutput from Distribution Substations	1211.47	4,224,631
Adjusted Distribution Substation Losses	6.94	25,506
Input to Distribution Substations	1218.41	4,250,137
Distribution Substation Loss Factor	**1.00573**	**1.00604**
Retail Sales at from SubTransmission	274.00	2,111,724
Req. Whls Sales from SubTransmission	7.00	25,240
Input to Distribution Substations	922.51	3,240,551
Output from SubTransmission	1213.83	5,326,889
Adjusted SubTransmission System Losses	28.17	75,111
Input to SubTransmission	1242.00	5,402,000
SubTransmission Loss Factor	**1.02321**	**1.01410**
OUT DISTR SUBS	289.00	1,015,200
Retail Sales at from Transmission	37.00	377,733
Req. Whls Sales from Transmission	15.00	70,105
Input Subtransmission	1101.88	4,650,435
Output from Transmission	1442.88	6,113,473
Adjusted Transmission System Losses	65.42	181,715
Input to Transmission	1508.30	6,295,188
Transmission Loss Factor	**1.04534**	**1.02972**

DEMAND MW — **SUMMARY OF LOSSES AND LOSS FACTORS BY DELIVERY VOLTAGE** — **EXHIBIT 9**
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	SERVICE LEVEL		**SALES MW**	**LOSSES**	**SECONDARY**	**PRIMARY**	**SUBSTATION**	**SUBTRANS**	**TRANSMISSION**
1	**SERVICES**								
2	SALES		1,089.71		1,089.7				
3	LOSSES			9.0	9.0				
4	INPUT				1,098.7				
5	**EXPANSION FACTOR**	**1.00827**							
6	**SECONDARY**								
7	SALES								
8	LOSSES			7.9	7.9				
9	INPUT				1,106.6				
10	**EXPANSION FACTOR**	**1.00715**							
11	**LINE TRANSFORMER**								
12	SALES								
13	LOSSES			17.9	17.9				
14	INPUT				1,124.5				
15	**EXPANSION FACTOR**	**1.01620**							
16	**PRIMARY**								
17	SECONDARY				1,124.5				
18	SALES		60.00			60.0			
19	LOSSES			27.0	25.6	1.4			
20	INPUT								
21	**EXPANSION FACTOR**	**1.02277**							
22	**SUBSTATION**								
23	PRIMARY				1,150.1	61.4			
24	SALES		0.0						
25	LOSSES			6.9	6.6	0.4			
26	INPUT				1,156.7	61.7			
27	**EXPANSION FACTOR**	**1.00573**							
28	**SUB-TRANSMISSION**								
29	DISTRIBUTION SUBS				847.5	75.0			
30	SALES		281.00					281.0	
31	LOSSES			28.2	19.7	1.7		6.5	
32	INPUT				867.2	76.7		287.5	
33	**EXPANSION FACTOR**	**1.02321**							
34	**TRANSMISSION**								
35	SUBTRANSMISSION				615.7	54.5		287.5	
36	DISTRIBUTION SUBS				302.3	-13.3			
37	SALES		52.00						52.0
38	LOSSES			65.4	41.6	1.9		13.0	2.4
39	INPUT				946.3	43.1		300.6	54.4
40	**EXPANSION FACTOR**	**1.04534**							
41	**TOTALS** LOSSES	CALCULATED		162.3	128.3	5.3		19.6	2.4
		SCALED		162.3	135.0	5.3		19.6	2.4
42	% OF TOTAL			100%	83.20%	3.27%		12.05%	1.45%
43	SALES		1,482.7		1,089.7	60.0		281.0	52.0
44	% OF TOTAL		100.00%		73.49%	4.05%		18.95%	3.51%
45	INPUT		1,645.0		1,224.7	65.3		300.6	54.4
46	**CUMMULATIVE EXPANSION LOSS FACTORS** (from meter to system input)				**1.12391**	**1.08856**	**NA**	**1.06960**	**1.04534**

ENERGY MWH **SUMMARY OF LOSSES AND LOSS FACTORS BY DELIVERY VOLTAGE** **EXHIBIT 9**
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	SERVICE LEVEL			SALES	LOSSES	SECONDARY	PRIMARY	SUBSTATION	SUBTRANS	TRANSMISSION
1	**SERVICES**									
2	SALES			3,608,038		3,608,038				
3	LOSSES				15,676	15,676				
4	INPUT					3,623,714				
5	**EXPANSION FACTOR**		**1.00434**							
6	**SECONDARY**									
7	SALES									
8	LOSSES				10,367	10,367				
9	INPUT					3,634,081				
10	**EXPANSION FACTOR**		**1.00286**							
11	**LINE TRANSFORMER**									
12	SALES									
13	LOSSES				97,825	97,825				
14	INPUT					3,731,905				
15	**EXPANSION FACTOR**		**1.02692**							
16	**PRIMARY**									
17	SECONDARY					3,731,905				
18	SALES			454,438.000			454,438			
19	LOSSES				38,288	34,132	4,156			
20	INPUT									
21	**EXPANSION FACTOR**		**1.00915**							
22	**SUBSTATION**									
23	PRIMARY					3,766,037	458,594			
24	SALES			0						
25	LOSSES				25,506	22,737	2,769			
26	INPUT					3,788,774	461,363			
27	**EXPANSION FACTOR**		**1.00604**							
28	**SUB-TRANSMISSION**									
29	DISTRIBUTION SUBS					3,180,551	60,000			
30	SALES			2,136,964					2,136,964	
31	LOSSES				75,111	44,847	846		30,132	
32	INPUT					3,225,398	60,846		2,167,096	
33	**EXPANSION FACTOR**		**1.01410**							
34	**TRANSMISSION**									
35	SUBTRANSMISSION					1,935,239	60,846		2,167,096	
36	DISTRIBUTION SUBS					613,837	401,363			
37	SALES			447,838						447,838
38	LOSSES				181,715	75,768	11,930		64,414	13,311
39	INPUT					2,624,844	413,293		2,231,510	461,149
40	**EXPANSION FACTOR**		**1.02972**							
41	**TOTALS**	LOSSES	Calculated		444,487	301,351	19,701		94,546	13,311
			Scaled		444,488	310,103	26,528		94,546	13,311
42		% OF TOTAL			100%	67.80%	4.43%			2.99%
43		SALES		6,647,278		3,608,038	454,438		2,136,964	447,838
44		% OF TOTAL		100.00%		54.28%	6.84%		32.15%	6.74%
45		INPUT		7,091,766		3,918,141	480,966		2,231,510	461,149
46	**CUMMULATIVE EXPANSION LOSS FACTORS** (from meter to system input)					**1.08595**	**1.05837**	**NA**	**1.04424**	**1.02972**

Appendix B

Discussion of Hoebel Coefficient

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COMMENTS ON THE HOEBEL COEFFICIENT

The Hoebel constant represents an established industry standard relationship between peak losses and average losses and is used in a loss study to estimate energy losses from peak demand losses. H. F. Hoebel described this relationship in his article, "Cost of Electric Distribution Losses," Electric Light and Power, March 15, 1959.

Within any loss evaluation study, peak demand losses can readily be calculated given equipment resistance and approximate loading. Energy losses, however, are much more difficult to determine given their time-varying nature. This difficulty can be reduced by the use of an equation which relates peak load losses (demand) to average losses (energy). Once the relationship between peak and average losses is known, average losses can be estimated from the known peak load losses.

Within the electric utility industry, the relationship between peak and average losses is known as the loss factor. For definitional purposes, loss factor is the ratio of the average power loss to the peak load power loss, during a specified period of time. This relationship is expressed mathematically as follows:

$$(1)\quad F_{LS} \cong A_{LS} \div P_{LS}$$

where: F_{LS} = Loss Factor
A_{LS} = Average Losses
P_{LS} = Peak Losses

The loss factor provides an estimate of the degree to which the load loss is maintained throughout the period in which the loss is being considered. In other words, loss factor is the ratio of the actual kWh losses incurred to the kWh losses which would have occurred if full load had continued throughout the period under study.

Examining the loss factor expression in light of a similar expression for load factor indicates a high degree of similarity. The mathematical expression for load factor is as follows:

$$(2)\quad F_{LD} \cong A_{LD} \div P_{LD}$$

where: F_{LD} = Load Factor
A_{LD} = Average Load
P_{LD} = Peak Load

This load factor result provides an estimate of the degree to which the load loss is maintained throughout the period in which the load is being considered. Because of the similarities in definition, the loss factor is sometimes called the "load factor of losses." While the definitions are similar, a strict equating of the two factors cannot be made. There does exist, however, a relationship between these two factors which is dependent upon the shape of the load duration curve. Since resistive losses vary as the square of the load, it can be shown mathematically that the loss factor can vary between the extreme limits of load factor and load factor squared. The

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relationship between load factor and loss factor has become an industry standard and is as follows:

$$(3)\ F_{LS} \cong H*F_{LD}^2 + (1-H)*F_{LD}$$

where:

F_{LS}	=	Loss Factor
F_{LD}	=	Load Factor
H	=	Hoebel Coefficient

As noted in the attached article, the suggested value for H (the Hoebel coefficient) is 0.7. The exact value of H will vary as a function of the shape of the utility's load duration curve. In recent years, values of H have been computed directly for a number of utilities based on EEI load data. It appears on this basis, the suggested value of 0.7 should be considered a lower bound and that values approaching unity may be considered a reasonable upper bound. Based on experience, values of H have ranged from approximately 0.85 to 0.95. The standard default value of 0.9 is generally used.

Inserting the Hoebel coefficient estimate gives the following loss factor relationship using Equation (3):

$$(4)\ F_{LS} \cong 0.90*F_{LD}^2 + 0.10*F_{LD}$$

Once the Hoebel constant has been estimated and the load factor and peak losses associated with a piece of equipment have been estimated, one can calculate the average, or energy losses as follows:

$$(5)\ A_{LS} \cong P_{LS} * [H*F_{LD}^2 + (1-H)*F_{LD}]$$

where:

A_{LS}	=	Average Losses
P_{LS}	=	Peak Losses
H	=	Hoebel Coefficient
F_{LD}	=	Load Factor

Loss studies use this equation to calculate energy losses at each major voltage level in the analysis.