DISTRIBUTION SYSTEM STUDY

Prepared for

City of Eudora, Kansas

Prepared by

Sawvel and Associates, Inc.

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Consultants and Engineers

EXECUTIVE SUMMARY

Sawvel and Associates, Inc. (Sawvel) prepared this Distribution System Study to assist the City of Eudora, Kansas (City) in planning for future growth in the City and to provide background information about the electric system that may be helpful to future staff employed by the City to maintain and improve the electric system.

This report provides recommendations regarding maintenance and suggested levels of continued investment in electric system assets that will continue the City's history of providing reliable electric service to its citizens and customers.

In summary, the electric system is in good condition. The system is unusual as compared to many other electric systems in that it was converted from 4.16 kV operation to 12.47 kV operation approximately 25 years ago (approx. 1995). When the system was converted, the majority of transformers, poles and conductor were replaced and now are approximately 25 years old. The loop in the center of the system has 72 poles that are 1970s vintage. Most electric systems' age of equipment can vary from 1 to 50 years old depending on the area of the system. The Eudora electric system is unique because the age of the system is similar in most areas of the system, and, because the system does not have extremely old equipment that is near its end of life.

The expected life of most electric utility equipment is 35 to 40 years if maintained properly. For instance, the life of a wood pole can depend on the acidity of the soil around the base of the pole and its exposure to natural elements such as snow, rain, wind and etc. A lot of the poles owned by the City are not exposed to extreme conditions like those that can occur in more rural areas in Kansas. However, the buried portion of the pole is susceptible to decay. Periodic pole testing and treating is important to prolong the life of the poles. While the electric system may not be as aged as other electric systems, proper maintenance and continued assessment of the condition of poles, transformers, substation circuit breakers and ancillary equipment is necessary to provide reliable service to the electric customers.

The electric system is served by four City-owned 12.47 kV distribution feeders that are energized from a Westar Energy-owned substation located south of the City. The City does not own a substation with transformers because the Westar substation transforms the voltage from the transmission voltage of 115 kV to the distribution voltage of 12.47 kV. The Westar substation was constructed in the late 1990s when the City's electric system was converted to 12.47 kV operation. The City uses approximately 55% of the capacity of the Westar substation.

The City owns a 12.47 kV switching station that is adjacent to and connected to the Westar substation. The switching station is the origin point of the City's four feeders. The station includes breakers and re-closers for each of the existing feeders. Up to four additional new feeders can be served from the switching station when needed. A circuit breaker will need to be added for each feeder position when adding a new feeder.

The electric system currently does not need additional substations to serve its electric load. It would not be practical or economical for the City to build its own substation to replace the Westar substation to serve the existing feeders. The Westar substation is adequate to serve the existing feeders. If and when the load growth shown later in this report actually occurs, Westar may need to add or replace transformers in its substation to serve Eudora. More information about the Westar substation is discussed later in this report.

The important capital expenditures needed to keep the system in good condition are replacing poles, service transformers and conductor before they fail and replacing underground distribution cable before it fails. Underground cable locations (by residential subdivision) and condition are as follows:

1. Hunter's Ridge – 1970s vintage, direct buried concentric neutral, approximately half of the cable in this area has been replaced. This cable is not in conduit. Cable is failing in this subdivision. This cable is over 40 years old.

2. Prairie Estates – 1990s vintage, cable is in conduit and has not experienced failures.

3. Winchester – 1990s vintage, direct buried with jacketed neutral. This cable has not experienced failures.

4. Shadow Ridge – 2005 vintage and newer, cable is in conduit, has not experienced failures.

5. Wakarusa Ridge – 1995 vintage and newer, cable is in conduit, has not experienced failures.

6. Meadowlark – 1995 vintage and newer, in conduit, has not experienced failures.

7. Intech Business Park – 1980s vintage, concentric neutral and is direct buried, cable has experienced failures, over 30 years old.

8. Greenway Addition – 1990s vintage, not in conduit, has not experienced failures

9. Grand Addition – 1990s vintage and newer, in conduit, has not experienced failures

10. Whispering Meadows – 1990s vintage and newer, in conduit, has not experienced failures.

The underground cables in Hunter's Ridge and Intech Business Park are inadequate to provide long term reliable service because they are direct buried (not in conduit), the cable construction is concentric neutral, has lesser insulation than newer cable used by the City and have experienced failures. Direct buried cable is susceptible to soil moisture and acidity and to damage from dig-ins. Most of the newer cable is in conduit that protects the cable from these possible sources of damage. The underground cables in these two areas should be replaced as soon as possible.

RECOMMENDATIONS

Table ES-1 shows projected capital improvement expenditures. The projected capital improvements are largely to replace equipment that is failing and that is nearing the end of its service life. The electric system feeders and the switching station have adequate capacity to serve load growth except for the Downtown and Winchester feeders.

The following briefly describes the capital improvements shown in Table ES-1.

1. Intech Business Park – This improvement replaces aged equipment that has experienced failure in the past.

2. & 3. The Winchester and Hunter's Ridge subdivisions are served by old underground cable that has experienced failures.

4. A Supervisory Control and Data Acquisition System (SCADA) is used to monitor and control the system and is useful in identifying the cause and location of service outages.

5. and 7. The Downtown and Winchester Feeders each need a second underground cable from the substation to the overhead line riser pole immediately outside of the substation so that the Downtown and Winchester feeders can be used as a backup to the other feeders without overloading the existing underground cables located at the substation.

6. A new breaker in the switching station will be used for a fifth feeder.

8., 9. & 10. Improvements 8, 9 and 10 are suggested planned replacements of equipment on a regular annual schedule based on replacing equipment on a 40 year useful life schedule. These expenditures reflect that the electric system will need to replace underground cable

and replace poles and service transformers to maintain reliable service. All of the capital improvements, except for the SCADA system, have useful lives of 40 years. The average annual capital expenditures for the 2020 to 2024 period is approximately $360,000.

The City should recover the cost of these expenditures over a longer period of time comparable to the useful lifetime of the equipment. This approach is consistent with rate making principles related to charging customers who are using the equipment over a long period of time. To accomplish capital recovery commensurate with useful life of equipment, the City should consider borrowing money for the larger projects for at least a 20 year amortization period and preferably for 30 years.

Other Observations

1. Electric system staff should patrol the electric lines periodically (at least once per year) to observe any equipment that is damaged, loose, or otherwise not in an acceptable condition. Problems should also be noted as linemen drive around the system for other reasons to catch problems that could cause a service outage. For instance, trees near wires, broken guy wires, damaged poles, transformers and etc.

2. As part of the electric utility maintenance, the City should use infrared thermography to scan the service transformers and line connections every two years for indications of loose connections and hot spots that may indicate impending equipment failure.

3. The City should test its electric meters periodically. Large power customer meters should be tested every year. Other meters can be tested every 5 years. This should be done in coordination with the City's Advanced Metering Infrastructure (AMI) equipment vendor.

4. The electric utility maintains maps of its electric distribution system. The maps are useful when responding to service outage calls and are an aid to maintaining the system. The maps are somewhat out of date and should be updated annually.

5. Currently, electric system staff members observe and log feeder phase amperage data on Monday morning of each week. The maximum amperage is logged from the preceding 7 day period. The date and time of peak is not recorded by the software. The instantaneous amperage on Monday morning is logged also. It would be useful to save the date and time of the maximum amperage of each week and keep this information along with the amperage readings in an electronic format such as Excel. Then this data can later be easily analyzed and reviewed. The weekly log should include an observation of conditions of equipment in the switching station. The log should include an indication of

satisfactory conditions or if problems are observed.

6. City staff have documented the times when outage calls begin. For a recent period of time, this information was not documented. One of the key performance measures of an electric utility is the amount of time that customers are out of service. The American Public Power Association keeps outage statistics and the electric industry also maintains industrywide outage data to which the City could compare itself. Currently, the City does not document the duration of the outage and thus, cannot measure the amount of time that customers' service is interrupted. It would be useful to keep more detailed outage event data so that the cause of outages can be identified and appropriately resolved. Then, the City can compare its outage statistics with other utilities to measure the electric system performance.

ES-1
Projected Capital Improvements
($)
City of Eudora, KS

	Description	Cost (2019$)	2020[1]	2021[1]	2022[1]	2023[1]	2024[1]	2034[1]
1	Intech Park (Riser Pole and Switch Cabinet)	169,169	169,169	-	-	-	-	-
2	Winchester Subdivision - Replace Underground	132,000	66,000	66,000	-	-	-	-
3	Hunters Ridge- Replace Underground	171,697	-	94,398	44,452	32,847	-	-
4	SCADA System	118,501	-	28,325	29,175	30,050	30,951	-
5	Second 500 MCM Alum. Cable (Winchester Feeder)	209,090	-	103,000	106,090	-	-	-
6	Add New Breaker for Feeder #5	87,524	-	-	-	87,524	-	-
7	Second 500 MCM Alum. Cable (Downtown Feeder)	225,102	-	-	-	-	225,102	-
8	Replace Poles - 23 per Year[2]	60,342	60,342	62,153	64,017	65,938	67,916	91,273
9	Replace Transformers - 17 per Year[3]	71,023	71,023	73,154	75,349	77,609	79,937	107,429
10	Replace Residential Underground (2034 and After)[4]	-	-	-	-	-	-	1,743,724
	Total Cost ($)	1,244,449	366,535	427,030	319,082	293,968	403,907	1,942,426

[1] All costs increased 3% annually to account for inflation.

[2] Summed the Single and Three Phase pole costs from the "Distribution System Value Summary" and divided by 40 years ($60,342/year = $2,413,696 / 40 years)

[3] Divided the total cost of Transformers - In Service from the "Distribution System Value Summary by 40 years ($71,023/year = $2,840,935 / 40 years).

[4] Residential underground conductor replacement for the following neighborhoods: Shadow Ridge, Meadowlark, Grand Addition, Greenway, Whispering Meadows, and Wakarusa Ridge. Total conductor length of 10.60 miles with a cost of $105,598 per mile).

PURPOSE AND APPROACH

INTRODUCTION

This is the Distribution System Plan Report prepared for the Eudora (City) electric system. The study includes a review of the existing system, recommends near term system improvements and long-term improvements.

PURPOSE

The purpose of the Distribution System Plan (Study) is to assist the City of Eudora, Kansas (City) with a practical guide for the economical development of the electric system. The purpose of this Study is to review the existing distribution system, identify improvements and develop a distribution system plan with a schedule of improvements. The schedule of improvements includes cost estimates for budgeting purposes.

APPROACH

The approach to preparing the Study involved completing several tasks. These tasks include:

Task 1 – Collect and Review Data

The first task includes requesting and collecting data and information. The data and information needed for this project included:

1. Existing distribution system map including the following information:
    a. Substation
    b. Feeders
        i. Conductor size for each segment
        ii. Identify each feeder segment as 1-, 2-, or 3-phase
        iii. Identify feeder segment as overhead or underground
    c. Poles
        i. Age
        ii. Height
        iii.Class
    d. Service Transformers
        i. Size in kVA

ii. Single or Three-Phase identification

iii. Pole-mount or Pad-Mount identification

iv. Which phase of the feeder the transformer is connected if it is a single phase transformer on a multi-phase section of feeder

e. Any Fuses, Switches or Breakers on the feeders

f. Any GIS data associated with the map (pole height, class, cross-arm size)

2. Historical feeder loading data (kW, kVA, kVAr, Amps, power factor for each phase of each feeder).

   a. If the City has monthly logs with this information, please provide 2015, 2016 and 2017 monthly information.

   b. If the City does not have monthly information, please indicate the date and time for the historical loading data provided.

3. Large customer historical load information and location.

4. Projected feeder load growth.

Task 1 included a site visit to collect distribution system information that was used to assess and evaluate feeders, observe poles and transformers on each feeder, review existing configuration and discuss maintenance, reliability and performance of the distribution system. During the site visit, Sawvel drove the system with a City representative.

Task 2 – Analyze the Existing System

The existing system feeder loading and feeder capacity compared and analyzed. A spreadsheet model was prepared to evaluate the existing feeder loading. The model indicates the capacity and loading for each feeder. The analysis was used to identify feeders that maybe inadequate to serve current or future customers.

Task 3 – Develop Feeder Load Forecasts

Sawvel coordinated with the City to forecast load growth and evaluate the adequacy of feeder capacity to serve future load growth. Feeder load growth potential from City zoning and planning maps were used to identify areas of the system that load growth might be expected.

Task 4 – Analyze Future System Configuration

The spreadsheet model was used to analyze the future system improvements. This evaluation included an evaluation of future feeder capacity and loading.

Task 5 – Develop Distribution System Improvement Cost Estimates

The proposed system improvements were organized into a chronologically scheduled distribution system plan. Sawvel prepared system improvement cost estimates for the capital improvements.

Task 6 – Prepare Final Report

This Report was prepared to describe the distribution system capital improvement plan.

DESCRIPTION OF EXISTING SYSTEM

The City owns and operates a municipal electric utility system that was established in 1917. In 2018, electric system peak demand was approximately 12.9 MW and retail energy sales were approximately 42,158,000 kWh. The Eudora electric system primarily serves the Eudora Area. The service territory generally is bounded by the Wakarusa River to the north and west, 1200 Road/28th Street to the south and 2300 Road to the east. The Electric System provides service to 2,405 residential, 215 commercial, and 1 large power customers. The City electric system total revenues were approximately $5,000,000 in 2018.

The City has historically purchased all of its electric system energy requirements from other electric utilities and does not own any electric generators for supplying its electric customers. For many years, the City purchased its wholesale energy requirements from Westar Energy. The Power Supply Agreement with Westar Energy terminated on May 31, 2013. The City conducted a Request for Proposals for power supply resources prior to the termination of the Westar Energy Agreement. The City chose to purchase its capacity and energy requirements from the Kansas City Power and Light Company (KCP&L) beginning on June 1, 2013.

POWER SUPPLY

The City is a member of the Kansas Municipal Energy Agency (KMEA). KMEA schedules capacity and energy from the City's purchase power suppliers on behalf of the City. The City currently purchases capacity and energy from the Kansas City Power & Light Company, (KCP&L) and the Western Area Power Administration (WAPA).

KMEA

KMEA was created by its Member cities as a joint action agency to develop projects that supply electric power to the Members' municipal electric utilities and to provide services to its Members such as scheduling capacity and energy. KMEA charges the Members for the actual expenditures incurred to provide its services.

KMEA has contracted with power suppliers and transmission providers on behalf of the Members that participate in specific power supply arrangements. KMEA has contracts with each participating Member for a proportionate share of the power supply on the same terms and at the same costs KMEA is obligated to pay under power supply and transmission contracts, plus an administrative fee for KMEA. The administrative fee is established by the Members on an annual basis.

KMEA and the City have executed a Master Service Agreement that provides ancillary services associated with delivering capacity and energy to the City's electric system. KMEA is responsible for managing transmission arrangements, load projections, scheduling, and market services. In summary, KMEA is responsible for the following services:

1. Schedule energy from KCP&L to the City
2. Schedule and manage SPP Transmission Service
3. Schedule energy from Western Area Power Administration (WAPA)
4. Review KCP&L, WAPA energy invoices, and SPP transmission invoices
5. Bill the City for all power supply costs and provide payment to the City's power suppliers (City pays direct to KCP&L).

Western Area Power Administration

The City has an allocation of capacity and energy from the Western Area Power Administration Project (WAPA). WAPA supplies firm hydroelectric capacity and energy. WAPA energy is scheduled for on-peak periods. WAPA demand and energy rates are set periodically and were most recently changed in January of 2017. The City allocation of WAPA is 619 kW and 474 kW in the summer and winter, respectively. WAPA is expected to provide approximately 1,689,800 kWh of energy annually. The WAPA Agreement terminates on September 30, 2024 and is expected to be extended past 2024.

KCP&L

The City purchases capacity and energy from KCP&L to serve the City's capacity and energy needs in excess of WAPA capacity and energy. The KCP&L agreement has a 10 year term with stated demand and energy rates for each year of the agreement. The term of the KCP&L Agreement is through December 31, 2028. This agreement was extended on June 1, 2018 as part of a settlement between KMEA and Great Plains Energy, Incorporated regarding the merger of Westar and KCP&L. The term of the original agreement was June 1, 2013 to May 31, 2023. The extension involved decreasing the capacity and energy prices, extending the term, and all other terms and conditions were unchanged.

KCP&L serves more than 820,000 customers in 47 northwestern Missouri and eastern Kansas counties – a service territory of approximately 18,000 square miles. It operates and maintains 3,000 miles of transmission lines, over 24,000 miles of distribution lines and 320 substations. KCP&L operates 15 generating facilities with over 6,100 megawatts of generation assets in

operation or under construction.

Westar

The electric system is interconnected with the Westar Energy substation at 12.47 kV. The interconnection is located at the Westar-Eudora Township Substation (Substation) south of the City and south of Highway K-10. The Westar Energy transmission system delivers electricity to nearly 700,000 customers in 55 counties.

The Westar Substation is located on the east side of 2100 Road approximately 1,500 feet south of 1300 Road. The Substation has two transformers. Table 1 lists the Westar transformers and their rated capacities. One transformer is a 115/13.09 kV transformer rated at 10,500 kVA at 65°C. The other transformer is a 115/13.09 kV transformer rated at 12,000 kVA. This information was obtained from the Westar Substation One-line diagram included at the end of this section.

Table 1
Westar-Eudora Township
Substation Transformers[(1)]
City of Eudora, Kansas

XFMR	Voltage (kV)	Rating (kVA) FA 65°C
2	115/13.09	10,500
3	115/13.09	12,000

[(1)] From Westar One-line diagram dated March 2014.

SUBSTATIONS

Eudora owns and operates a distribution system switching station that is located next to the Westar-Eudora Township Substation. The switching station has positions for 8 feeders. The station currently serves the existing four distribution system feeders and the remaining unused feeder positions can be used in the future for new feeders.

DISTRIBUTION SYSTEM

The distribution system consists of four 12.47 kV feeders that originate from the City's distribution switching station in the southern part of the electric system south of K-10. The feeders are made up of approximately 25 pole miles of overhead circuit and approximately 18 miles of underground circuit. The overhead construction is wood pole with 10 foot and 8 foot wooden cross-arms for three phase feeders. The predominant conductor used on 12.47 kV 3-

phase main feeders is T2 423 kcmil ACSR. Each feeder exits the switching station underground to a riser pole where the main feeder is overhead. The underground cable that exits the substation is 500 MCM Alum. Two of the feeder exits are 2 parallel 500 MCM Alum. cables to match the ampacity of the T2 423 kcmil ACSR overhead conductor. The Downtown and Winchester feeders only have one 500 MCM Alum. underground cable circuit exiting the station. A map of the electric system is included at the back of this report.

The four existing 12.47 kV feeders are described as follows:

- ***Winchester Feeder***

This feeder exits the Substation and heads north along 2100 Road then heads east along the south-side of 1300 Road for approximately 1,100 feet. The line turns to head north across K-10 highway and continues along the eastern edge of the Winchester subdivision. Then the line continues north along Cedar Street, crosses 1400 Road and continues north through a field. The line turns east at the Wastewater Treatment Plant and follows along 7th Street until its terminus approximately 400 feet east of Ash street. This feeder serves mostly residential customers from Cedar Street, east to Fir Street and from 6th street south to 14th Street. It serves the Winchester, Wakarusa Ridge and Hunter Ridge subdivisions.

- ***Downtown Feeder***

The Downtown feeder exits the Substation and the underground cable heads east for approximately 2,000 feet where the riser pole is located and then heads north as a three phase overhead line. This feeder serves customers in the Grand Addition, Greenway, and Grandview Trailer Park subdivisions. It also serves customers from Fir Street, east to Ash Street, and from 7th Street south to K-10 highway. The majority of the customers are residential with some commercial along Main Street from 7th Street south to 10th Street. The feeder also serves customers along 10th Street/CR442 from Acorn Street east to Peach Street.

- ***Prairie Estates Feeder***

This feeder leaves the substation and heads south for approximately 500 feet to a riser pole. Then the line heads east as a three phase overhead line to 2200 Road/Church Street where it serves residential customers in the Shadow Ridge and Meadowlark subdivisions. The line heads north along 2200 Road/Church Street crossing the K-10 highway and serves residential customers in the Whispering Meadows subdivision. The general service area of this feeder is Arrowwood Street on the west to Hickory Street on the east and 12th Street on the north to K-10 on the south. It also serves the area from K-10 south to 28th Street and from Fir Street to Church Street.

- ***Industrial Feeder***

The Industrial Feeder exits the substation and is on the same poles as the Prairie Estates feeder from the Substation to where the Prairie Estates feeder crosses K-10 highway. The Industrial Feeder continues northeast along K-10 highway for approximately 2,000 feet then turns north across K-10 highway into the Intech Business Park. The line goes underground and splits with 1) line continuing north to serve HP Pelzer and 2) continuing east and north to K-10 highway to supply the rest of the business park.

Maintenance

Regular maintenance is important to maintain reliable electric service. Several maintenance items are highlighted in the following paragraphs. The City electric system is served by a Westar substation that has generally been reliable. This section also includes some information regarding Westar's substation maintenance.

The City does not regularly test and treat its utility poles. The last time pole testing and inspection took place, 200 poles were tested and 30 to 40 poles were found to need replacement. With regular testing/inspection and treatment pole life can be improved beyond 45 years.

The City spends approximately $40,000 annually to trim trees near the distribution lines and poles. Maintaining good tree clearances helps the reliability of the system. Distribution Line Patrol efforts by the City are not organized and is patrolled if time allows. The system should be patrolled at a minimum of once per year to identify equipment that maybe in disrepair or failed.

Breaker/Recloser maintenance in the City switching station is completed by KEPCO every seven to 10 years. The Vacuum Breakers are 25 years old and were last opened and serviced in September 2014 to have the contacts reviewed and replaced if needed. Varmint Guards are used on the 12 kV circuit breakers in the Eudora Switching Station to deter animals from causing outages.

Infrared Thermography testing was completed six to seven years ago and found that a couple of substation connections needed to be fixed. Infrared testing should be used to catch possible problems before they fail. The City should budget for this testing every other year.

Reliability

City staff indicated that voltage readings on each of the feeders can be easily retrieved from the City's Advanced Metering Infrastructure (AMI) system customer meters. At the substation, voltage is maintained at between 122 Volts and 123 Volts on a 120 Volt base. Electric utility

staff indicated that the feeders have maintained adequate voltage during normal operating conditions and that the City has not recently received low voltage complaints from customers.

The City has some performance measurements when service is interrupted, but is missing the outage duration.

City staff indicated that the Westar substation has been very reliable since it has been in service. Westar provided the following information about its substation:

1. In the event of damage of any kind to equipment in the substation, including the transformers, Westar would assess the damage and situation. If necessary, Westar has a mobile substation that would be used while permanent repairs are made. A spare transformer stored at Tecumseh Energy Center in the event of a transformer only failure in the substation.

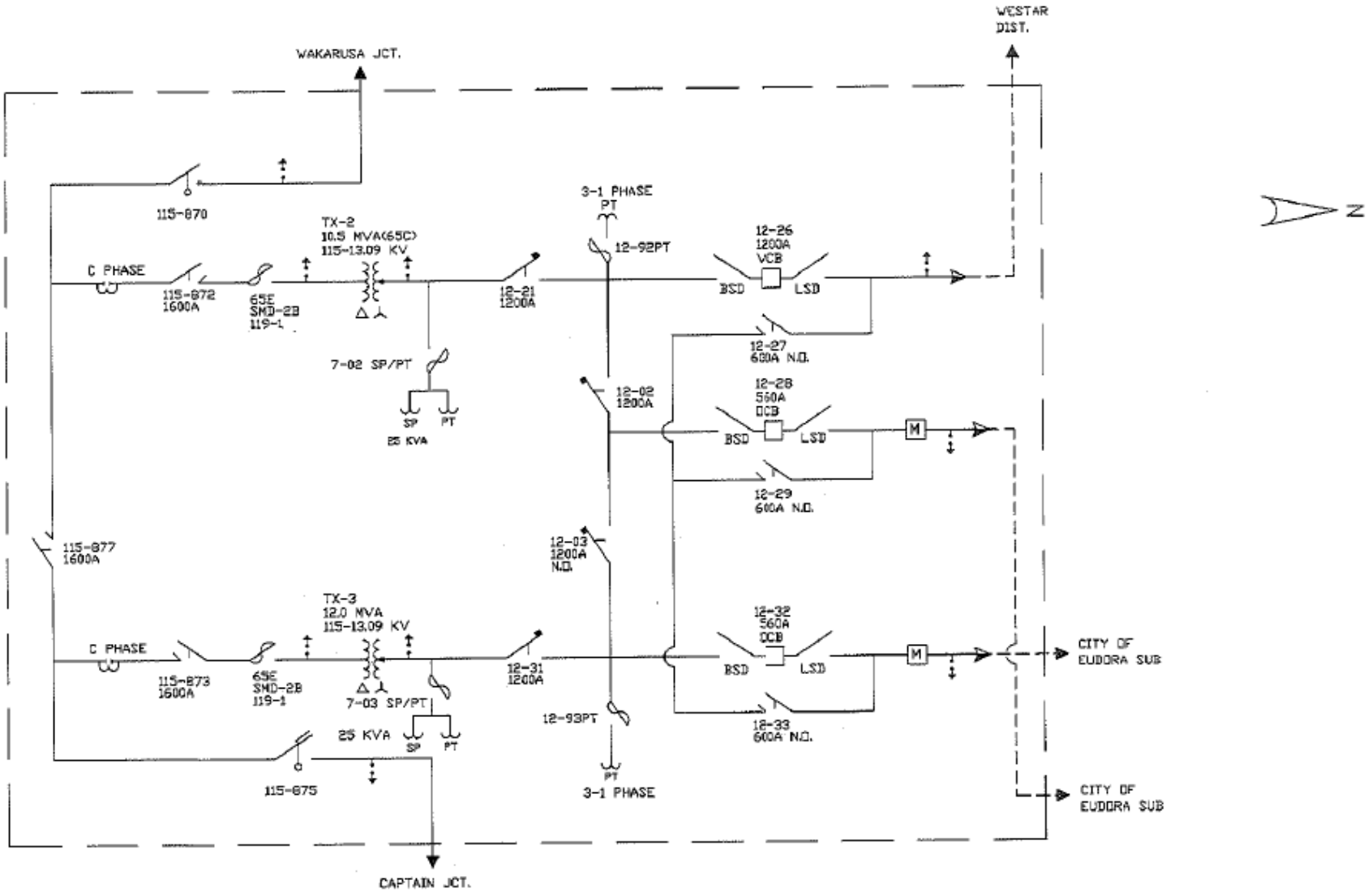
2. Westar has indicated that it currently has about 6.5 MW of spare capacity in the substation. The transformers were built in 1977 and 2000. The 12-32 circuit has about 3.5 MW of capacity and the 12-28 circuit has about 3.0 MW of capacity. Assuming that the other loads in the area served by Westar's Eudora Township substation remain constant, Westar would be able to serve additional load of 5 MW with the same facilities in place today. For any future load changes, Westar asked to be notified to ensure that Westar can plan appropriately for additional load growth. Westar would then evaluate improvements that are necessary and communicate to the City accordingly.

3. The Westar transformers in the Eudora Township substation are 42 years and 19 years old respectively. The 19 year old transformer was originally manufactured in 1982, but was rewound by SD Myers in 2000. Two of the 12 kV breakers are 35 years old and the third is 17 years old.

4. Westar's Substation Maintenance protocols include the following:
    a. Battery impedance testing is performed every year.
    b. Battery chargers are inspected every 3 years.
    c. Circuit breaker maintenance is performed every 12 years.
    d. Transformer main tank and LTC oil samples are taken for analysis every year.
    e. Relay testing is performed every 6 or 12 years, depending on the type of relay.
    f. Substation patrol inspections are performed every quarter.

g. Substation infrared inspections are performed every year.

The Westar substation went in service in 2000. There are a small number of Westar customers served from this substation, but the majority of the load served from this substation is for the City of Eudora. Prior to receiving service from this substation, the City was connected to Westar at a Westar-owned 34.5 kV substation located in the northeast corner of the City. There is not another logical or economical interconnection option for the City to build its own substation. It might be feasible at some time in the future that the City could purchase the Westar substation.



DIVISION: LAWRENCE LOCATION: 1264 E. 2100 RD., EUDORA

REV.	DESCRIPTION	DATE	BY/CK
4	CHANGED DESTINATION NAMES PER ENG.	3/14	TKR
3	ADDED ARRESTORS/REPLACED 12-03	10-12	MGD
2	ADDED BKR 12-26 PER A10406	2005	MGD
1	CONVERTED FROM CABLECAD	1-03	MGD

DRAWN BY _____ DATE _____
CHECKED BY _____ DATE _____
APPROVED BY _____ DATE _____
SCALE: NONE
WORK ORDER NO

Westar Energy™

TITLE
EUDORA TOWNSHIP
ONE LINE DIAGRAM
(EUDO)

DWG NO. S01260
SHEET NO. 1 OF 1
REV. 4

GROUP: 1 LINE USER: LAWRENCE CAD FILE NO.: EUDORA - S01260 R4

PLANNING CRITERIA

Planning criteria were developed to assess the adequacy of the distribution system, and used as a measure of acceptable system performance. These criteria are long-range planning criteria and meeting these criteria in the short term may be difficult in specific situations. Therefore, judgement should be used in determining what operating conditions can be tolerated in the short term until a long-term solution relieves a particular condition.

Throughout this section, normal and contingency conditions are referenced. Normal conditions refer to the operation of the system under peak loading conditions with all facilities in operation consistent with the Eudora distribution system map provided to Sawvel in May of 2019.

Contingency conditions refer to the outage of a distribution feeder or transformer during peak load conditions. The contingencies considered in this study were loss of substation transformers and feeders out of service.

Feeders should be supported by adjacent feeders throughout the system. Support from other feeders should be accomplished by performing a minimum of switching operations. These operations would typically be opening switches to isolate the failure and closing switches to reenergize the unfaulted portion from adjacent energized feeders. Although this redundancy is preferred, in some circumstances it may not be economical or technically feasible to provide such backup.

TRANSFORMER LOADING

Normal Conditions

The planning criteria require that a substation transformer be loaded no greater than 100 percent of its rated FA (forced air) 55 degrees Celsius capacity under normal conditions.

Contingency Conditions

Under contingency conditions (one element out of service), the transformer may be loaded to its FA rating at 65 degrees Celsius.

CONDUCTOR LOADING

Criteria for distribution conductor loading, under both normal and contingent conditions, requires that a conductor not be loaded greater than 100 percent of its thermal rating at a 25-

degree Celsius ambient temperature and a 50-degree Celsius temperature rise above ambient temperature resulting in a conductor temperature of 75 degree Celsius. Table 2 summarizes the ampacities and kVA ratings for each conductor type on the Eudora system.

While the loading on a feeder should not exceed the conductor rated capacity, normal loading on Eudora's feeders should not exceed 50% of rated capacity. The Eudora electric system is served from one substation south of the City. The feeders have to be able to back up each other through switches between the feeders throughout the electric system because there are no other substations that can provide an alternate source.

The predominant 3 phase feeder conductor, T2 423 kcmil ACSR, has a three phase main feeder capacity of approximately 12,000 kVa. So, the load on each feeder during normal operation should not exceed 6,000 kVa so that if two feeders are tied together during a service outage, the feeder will be loaded at no more than 100% of its rated capacity.

VOLTAGE LEVEL

Normal Conditions

The acceptable transmission system voltage range during normal operation is 95 to 105 percent. In accordance with RUS bulletin 1723D-113, the unregulated voltage drop on the distribution system should not exceed 8 volts from the substation to the end of the circuit.

Contingency Conditions

During contingency conditions transmission bus voltages should not fall below 0.95 per unit. The voltage on the distribution system may drop to 110 volts or a 10-volt drop from the substation (if 120 volts).

POWER FACTOR

The system power factor should be at least 95% during peak demand periods.

GOALS

The feeder load at the substation should be balanced between phases plus or minus 15%. It may not be necessary or practical to balance every feeder. However, phase balancing reduces the conductor load and improves voltage on the feeder.

DISTRIBUTION SYSTEM RELIABILITY CRITERIA

1. All 3 phase feeders use T2 423kcmil ACSR phase conductor except for Prairie Estates which uses 477 kcmil ACSR. These conductor sizes are appropriate for the electric system.
2. All Feeders except the Downtown and Winchester feeders should be loaded at less than 50% of T2 433 kcmil ACSR conductor capacity (560 Amps, 12,095 kVA). The Downtown and Winchester feeders currently are rated at approximately 6,700 kVa because the underground cable that exits the substation is only one 500 MCM Alum. cable. Thus, it can only provide approximately 3,350 kVa of back up to other feeders.
3. Substation transformers should not exceed 100% of the OA/FA/FA @ 55 degrees C rated capacity under normal loading conditions The transformer ratings are as follows:
    a. Westar Substation transformer 2 can be loaded to 10,500 kVA during emergency conditions.
    b. Westar Substation transformer 3 can be loaded to 12,000 kVA during emergency conditions

Currently the goal would be that substation transformers should be normally loaded no greater than 50% of rated capacity during normal peak load conditions in case one of the transformers is out of service. It is important to note that the Westar substation transformers are the responsibility of Westar and **not the City**.

Table 2
Feeder Conductor Ratings
City of Eudora, Kansas

Feeder	Conductor	OH or UG	Operating Voltage (kV)	Conductor Rating	
				Ampacity [1]	kVA
Winchester	T2 423 kcmil ACSR	OH	12.47	560	12,095
	4/0 ACSR	OH	12.47	357	7,711
	397 kcmil ACSR	OH	12.47	576	12,441
	500 MCM Alum.	UG	12.47	310	6,696
Downtown	T2 423 kcmil ACSR	OH	12.47	560	12,095
	4/0 ACSR	OH	12.47	357	7,711
	500 MCM Alum.	UG	12.47	310	6,696
Prairie Estates	477 kcmil ACSR	OH	12.47	646	13,953
	4/0 ACSR	OH	12.47	357	7,711
	500 MCM Alum.[2]	UG	12.47	310	6,696
Industrial	T2 423 kcmil ACSR	OH	12.47	560	12,095
	4/0 ACSR	OH	12.47	357	7,711
	500 MCM Alum.[2]	UG	12.47	310	6,696
	4/0 Alum.	UG	12.47	180	3,888
Spare Feeder	750 MCM Alum.[3]	UG	12.47	385	8,315

[1] Based on a conductor temperature of 75 degrees Celsius, an ambient temperature of 25 degrees Celsius and 2 ft/sec cross wind.

[2] Two 500 MCM cables from substation to riser pole.

[3] Runs concurrently with Winchester, but dead ends underground.

EXISTING SYSTEM ANALYSIS

Eudora's distribution system map included at the end of this report was used to obtain data including feeder locations and service conductor sizes. These maps were supplemented with information obtained from Eudora staff and during site visits. Feeder loading information was obtained from feeder phase amp logs.

DATA BASE DEVELOPMENT

The data described in the previous section was compiled and entered into an analysis spreadsheet. The data was then used to prepare the feeder peak demands by analyzing the dates and times of readings compared to the peak demand of the electric system.

DISTRIBUTION SYSTEM ANALYSIS

A feeder voltage drop analysis was not prepared for this effort. The City feeders are generally no longer than 3 miles in length and should not experience voltage drops that would exceed the planning criteria if configured and operated properly. The City has indicated that during normal conditions, feeder voltages are adequate based on readings from the AMI system.

Each feeder in the system was analyzed to determine conductor loading under peak loading conditions. Table 3 lists the feeder peak demand at the substation in amperes per phase and in kW and kVA during the week of July 17, 2018.

Table 3
2018 Feeder Peak Demand
System Peak Week July 17, 2018
City of Eudora, Kansas

Feeder	Week	Phase Amps[1]			Demand (kVA)[2]				Conductor			
		A	B	C	A	B	C	Total	Type	Capacity Amps	Capacity (kVA)	Loading (%)
Winchester	7/17	234	239	274	1,713	1,749	2,006	5,468	500 MCM Alum.	310	6,696	81.7
Downtown	7/17	158	96	69	1,157	703	505	2,364	500 MCM Alum.	310	6,696	35.3
Prairie Estates	7/17	175	156	241	1,281	1,142	1,764	4,187	477 kcmil ACSR	646	13,953	30.0
Industrial	7/17	73	75	65	534	549	476	1,559	T2 423 kcmil ACSR	560	12,095	12.9
System Total								**13,578**				

[1] Max Amps for previous week. From "Substation Readings 2016 and Up" spreadsheet provided by Eudora. Max Amps are located in columns G, P, Z and AI.

[2] kVA=Amps x V x boost. V equals 7.2kV per phone conversation. with Eldon Brown on 4/16/19. Boost is regulated voltage divided by base voltage (122/120=1.0167).

Analysis of Existing System

The existing system was analyzed by calculating feeder loading conditions in 2018. Table 3 summarizes conductor loading by feeder. The results of the feeder loading analysis are summarized in the following paragraphs. The analysis was during peak demand and normal conditions (no outages).

- ***Winchester Feeder***

The Winchester Feeder is loaded at 82% of rated capacity.

- ***Downtown Feeder***

The Downtown Feeder is loaded at 35% of rated capacity

- ***Prairie Estates Feeder***

The Prairie Estates Feeder is loaded at 30% of rated capacity

- ***Industrial Feeder***

The Industrial Feeder is loaded at 13% of rated capacity

All feeders are loaded at less than their rated capacity during normal conditions and less than 50% of rated capacity except the Winchester Feeder. The Winchester Feeder is loaded at 82% of its rated capacity.

- ***Westar Substation Transformers***

The transformers in the Westar Substation are loaded at 53% of rated capacity and have sufficient transformation capacity to serve the City's four feeders during normal conditions.

Feeder Contingency Analysis

If the Winchester or the Prairie Estates feeders are transferred to the Downtown feeder during peak load conditions, the Downtown feeder will be loaded at greater than 100 % of its rated capacity. Likewise, if the Downtown or Prairie Estates feeders are transferred to the Winchester feeder, the Winchester feeder will be loaded at greater than 100% of its rated capacity.

FEEDER LOAD FORECAST

APPROACH

The approach to the future system analysis involved projecting future load levels for each feeder. The next step involved analyzing feeder (conductor) loading. The planning criteria were applied to the future system analyses.

FEEDER LOAD PROJECTIONS

The feeder load projections were based on feeder peak demand information provided by City staff. The following steps were completed to develop the feeder load projections:

1. Growth potential in each feeder area was assessed on a qualitative basis.
2. Feeder projections based on growth potential and information from City staff were developed.

The City's population in 2018 is estimated at 6,384 by the U.S. Census Bureau. The population of Douglas County is projected to grow at approximately 1.2% annually over the 15 year period of 2019 to 2034 according to the Wichita State University Center for Economic Development and Business Research.

Future residential development is projected to occur in the Shadow Ridge and Meadowlark subdivisions located south of K-10 in an area north of the Intech Industrial Park and in an area west of the Grand Addition. Industrial growth is projected in the Intech Business Park located in the southeast quadrant of the service territory on the north side of K-10.

Feeder Growth Assumptions

Table 4 – Feeder Load Forecast shows the projected demand for each feeder. The following explains the projected feeder demands shown in Table 4.

- ***Winchester Feeder***

The Winchester Feeder is currently loaded at 5,500 kVA. The Winchester Feeder serves mainly residential areas that are largely fully developed. Load growth is not projected for the Winchester Feeder area.

- ***Downtown Feeder***

The Downtown Feeder is currently loaded at 2,400 kVA. The Downtown Feeder serves a mix of residential and commercial customers in the center of the City. Potential commercial growth could occur in the area occupied by an abandoned elementary school and in an area near K-10 on the east edge of the City. Residential growth is also possible in the area on the east edge of the City just north of the Intech Business Park and west of Grand Addition. The 2034 forecast shows a projected feeder demand of 4,900 kVA.

- ***Prairie Estates Feeder***

The Prairie Estates Feeder is currently loaded at 4,200 kVA. This feeder serves a mix of commercial and residential customers including the Shadow Ridge and Meadowlark subdivisions that are located south of K-10. Residential load growth is projected in the area south of K-10. The long term forecast shows a projected feeder demand of 5,200 kVA.

- ***Industrial Feeder***

The Industrial Feeder is currently loaded at 1,600 kVA. This feeder serves the Intech Business Park. If industrial customers are added in the Business Park, the electric load could increase by 5,000 kVA by 2034 and is projected at 6,600 kVA.

Table 4
Feeder Load Forecast
City of Eudora, Kansas

Feeder	Year (kVA)		
	2018	2024	2034
Winchester	5,468	5,468	5,468
Downtown[(1)]	2,364	3,114	4,864
Prairie Estates[(2)]	4,187	4,520	5,187
Industrial[(3)]	1,559	4,059	6,559
	13,578	17,162	22,078

[(1)] Increased 750 kVA by 2024 and 2,000 kVA by 2034. Growth is projected north of 10th Street and east of Peach Street to K-10 highway; Peach Street to the east edge of the Grandview Trailer Park south of 10th Street and west of Grand Addition.
[(2)] Increased 333 kVA by 2024 and 1,000 kVA by 2034. Growth is projected from 26th Street north to the city limits and west of Fir Street to the city limits in Shadow Ridge.
[(3)] Increased 2,500 kVA by 2024 and 5,000 kVA by 2034. Growth is projected within the Intech Business park.

ANALYZE FUTURE SYSTEM CONFIGURATION

DISTRIBUTION SYSTEM ANALYSIS

Each feeder in the system was analyzed to determine conductor loading under peak loading conditions. Each substation was analyzed by comparing existing transformation capacity to the 2019 and Long Term substation peak demands. Table 5 lists the feeder loading at the substation in kVA for the 2024 and 2034.

Table 5
2024 and 2034 Feeder Analysis
City of Eudora, Kansas

Feeder	Demand (kVA)		Conductor				
			Type	Capacity		Loading (%)	
	2024	2034		Amps	(kVA)	2024	2034
Winchester	5,468	5,468	500 MCM Alum.	310	6,696	81.7	81.7
Downtown	3,114	4,864	500 MCM Alum.	310	6,696	46.5	72.7
Prairie Estates	4,520	5,187	477 kcmil ACSR	646	13,953	32.4	37.2
Industrial	4,059	6,559	T2 423 kcmil ACSR	560	12,095	33.6	54.2
System Total	**17,162**	**22,078**					

Analysis of Future System

Two load levels were evaluated, the 2024 Plan and 2034 Plan. Table 5 shows the system peak demand of 17,200 kVA in 2024 and 22,100 kVA in 2034. The Future system was analyzed by calculating feeder loading for 2024 and 2034 load levels.

2024 Analysis

The results of the 2024 analysis are summarized in the following paragraphs. The analysis was during peak demand and normal conditions (no outages).

- ***Winchester Feeder***

The Winchester feeder was loaded at 82% of rated capacity.

- ***Downtown Feeder***

The Downtown feeder was loaded at 47% of rated capacity.

- ***The Prairie Estates Feeder***

The Prairie Estates feeder was loaded at 32% of rated capacity.

- ***Industrial Feeder***

The Industrial feeder was loaded at 34% of rated capacity.

2024 System Problems

1. The largest Westar Substation transformer would be loaded to approximately 143% of its emergency rating during the outage of the other transformer during peak conditions.

2034 Analysis

The results of the 2034 analysis are summarized in the following paragraphs. The analysis was during peak demand and normal conditions (no outages).

- ***Winchester Feeder***

The Winchester feeder was loaded at 82% of rated capacity.

- ***Downtown Feeder***

The Downtown feeder was loaded at 73% of rated capacity.

- ***The Prairie Estates Feeder***

The Prairie Estates feeder was loaded at 37% of rated capacity.

- ***Industrial Feeder***

The Industrial feeder was loaded at 54% of rated capacity.

2034 System Problems

1. The largest Westar Substation transformer would be loaded to approximately 184% of its emergency rating during the outage of the other transformer during peak conditions.

2. The Downtown feeder would be loaded greater than its rated capacity if any of the other feeders are transferred to it.

3. The Winchester feeder would be loaded greater than its rated capacity if any of the other feeders are transferred to it.

4. The Industrial feeder would be loaded at greater than 50 % of its rated capacity and would be loaded greater than its rated capacity if any of the other feeders are transferred to it.

CAPITAL IMPROVEMENTS

The projected capital improvements are largely to replace equipment that is failing and that is nearing the end of its service life. The electric system feeders and the switching station have adequate capacity to serve load growth except for the Downtown and Winchester feeders.

The following briefly describes the capital improvements.

1. Intech Business Park – This improvement replaces aged equipment that has experienced failure in the past.

2. and 3. The Winchester and Hunter's Ridge subdivisions are served by old underground cable that has experienced failures.

4. A Supervisory Control and Data Acquisition System (SCADA) is used to monitor and control the system and is useful in identifying the cause and location of service outages.

5. and 7. The Downtown and Winchester Feeders each need a second underground cable from the substation to the overhead line riser pole immediately outside of the substation so that the Downtown and Winchester feeders can be used as a backup to the other feeders without overloading the existing cables located at the substation.

6. A new breaker in the switching station will be used for a fifth feeder.

8. 9. and 10. Improvements 8, 9 and 10 are suggested planned replacements of equipment on a regular annual schedule based on replacing equipment on a 40 year useful life schedule.

Table 7, Distribution System Value, was used to estimate the value of the feeders including poles, crossarms and transformers. Electric meters and other equipment such as trucks and tools are not included. The information in Table 7 was used to estimate the costs of replacing poles and transformers that are shown in Table 6, Projected Capital Improvements.

APPENDIX A
CAPITAL IMPROVEMENT COST ESTIMATES

Table 6
Projected Capital Improvements
($)
City of Eudora, KS

	Description	Cost (2019$)	2020[1]	2021[1]	2022[1]	2023[1]	2024[1]	2034[1]
1	Intech Park (Riser Pole and Switch Cabinet)	169,169	169,169	-	-	-	-	-
2	Winchester Subdivision - Replace Underground	132,000	66,000	66,000	-	-	-	-
3	Hunters Ridge- Replace Underground	171,697	-	94,398	44,452	32,847	-	-
4	SCADA System	118,501	-	28,325	29,175	30,050	30,951	-
5	Second 500 MCM Alum. Cable (Winchester Feeder)	209,090	-	103,000	106,090	-	-	-
6	Add New Breaker for Feeder #5	87,524	-	-	-	87,524	-	-
7	Second 500 MCM Alum. Cable (Downtown Feeder)	225,102	-	-	-	-	225,102	-
8	Replace Poles - 23 per Year[2]	60,342	60,342	62,153	64,017	65,938	67,916	91,273
9	Replace Transformers - 17 per Year[3]	71,023	71,023	73,154	75,349	77,609	79,937	107,429
10	Replace Residential Underground (2034 and After)[4]	-	-	-	-	-	-	1,743,724
	Total Cost ($)	1,244,449	366,535	427,030	319,082	293,968	403,907	1,942,426

[1] All costs increased 3% annually to account for inflation.

[2] Summed the Single and Three Phase pole costs from the "Distribution System Value Summary" and divided by 40 years ($60,342/year = $2,413,696 / 40 years)

[3] Divided the total cost of Transformers - In Service from the "Distribution System Value Summary by 40 years ($71,023/year = $2,840,935 / 40 years).

[4] Residential underground conductor replacement for the following neighborhoods: Shadow Ridge, Meadowlark, Grand Addition, Greenway, Whispering Meadows, and Wakarusa Ridge. Total conductor length of 10.60 miles with a cost of $105,598 per mile).

Table 7
Distribution System Value Summary
City of Eudora, Kansas

	Number of Units[1]	Cost ($)
Single Phase		
Poles	250	390,900
Conductor	20	2,505,185
Subtotal		2,896,085
Three-Phase		
Poles	650	2,022,796
Conductor	24	5,805,985
Subtotal		7,828,781
Transformers - In Service		
Pole Mount	210	582,307
Padmount	469	2,258,628
Subtotal	679	2,840,935
Transformer - Inventory		
Pole Mount	64	105,874
Padmount	39	453,433
Subtotal	103	559,307
Total		**14,125,108**

[1] Conductor units are represented in "miles".