ELECTRIC SYSTEM
10-YEAR PLANNING STUDY

FOR

CITY OF
ASHLAND

ASHLAND, OREGON

JULY 2014

CVO
Electrical
Systems, LLC

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

A. PURPOSE

This report presents the results of a planning study of the City's electric system that is intended to be used as a management and planning tool. The primary goal is to provide realistic recommendations for the most practical and economic means of serving existing and future loads, while maintaining high quality service to customers with timely implementation of necessary equipment replacements and system improvements. The study evaluates the electric system strengths and weaknesses and identifies needed improvements based on projected load growth, anticipated energy costs, service quality, infrastructure condition, and most importantly reliability.

This report provides recommendations with detailed descriptions, schedules and cost estimates for replacement and upgraded infrastructure to meet future loads and/or replace and upgrade aging equipment. The study also addresses the agreements and costs associated with the City's power purchases from the Bonneville Power Administration (BPA) and Pacific Power (PacifiCorp). System improvements are suggested based on projected system load growth and changing electrical industry conditions with the aim of improving service quality and reliability while complying with construction, operating, and safety standards.

This study was conducted based on the best available information at the time. Some assumptions were necessary and are noted in the report. Any changes in equipment or system configuration from the data used in this report may require a change in recommendations. Except where noted, this study evaluated the system as it was configured at the time the study was performed.

With the passage of time, conditions generally change, and these changes can affect the feasibility or practicality of making some of the recommended improvements. This report should be reviewed and updated periodically since changing system conditions may affect the economic viability or integrity of the recommended plan. By following this approach, the City will maintain a valuable, up-to-date tool to aid management and staff in the process of system operation, planning, and expansion.

B. PROJECT AUTHORIZATION

In December 2013, the City of Ashland authorized CVO Electrical Systems to conduct a study of the City's electric distribution system. The study consists of various tasks as described in the CVO October 2013 Proposal. This report contains the results of the City's Electric Distribution System Study.

C. SCOPE OF WORK

The following is a summary of the scope of services performed in this study.

LOAD REVIEW & LOAD GROWTH FORECAST

Evaluate system-wide growth patterns based on historical, recent (last 10-year period) and expected future growth through 2023, based on information provided by the City, State, County, BPA, and PacifiCorp. This data is used to estimate future feeder and substation peak loading, load balance, system improvement needs, and for system analysis scenarios.

ESTABLISH SYSTEM PLANNING & DESIGN CRITERIA

Establish realistic planning criteria thresholds and objectives upon which short-term and long term planning action and improvements should be based. The criteria are used to determine loading and reliability guidelines, acceptable voltage drop levels, scheduling of improvements, and contingency plans under sectionalized and outage conditions.

SYSTEM EVALUATION

Evaluate the City's electric system and provide comments, observations, and recommendations in line with the established system planning and design criteria. The substations and City-owned distribution system are evaluated on the basis of equipment ratings, operating configurations, reliability, maintenance programs, vintage, condition, and equipment capacities compared with projected load forecasts. The transformation fee agreements with BPA and PacifiCorp are reviewed and different options for reducing total transformation costs to the City are evaluated.

The existing transmission system facilities serving the City are evaluated to determine interconnection and switching flexibility, looping capabilities, isolated segments, and overall operation of power supply to the City's electric system. The transmission system reliability, protection components, protective philosophy, and operational schemes are also considered to evaluate power availability, interruption frequency, proper device coordination, and emergency operating conditions.

POWER FLOW ANALYSIS

Analyze the City's complete electric system using the *EasyPower* analysis software. The system was modeled on a system-wide three-phase basis for the following conditions:

- Base Case 1A – normal system configuration under peak load conditions.
- Base Case 1B – normal system configuration under light load conditions.
- Five-Year Growth Case – projected peak load and cold weather conditions.
- Ten-Year Growth Case – projected peak load and cold weather conditions.
- Loss-of-Substation Transformer Cases (4) – model the loss of each substation transformer with load appropriately sectionalized to the other substations to serve all customers under peak conditions.
- Loss-of-Feeder Cases (10) – model each circuit out-of-service on an individual feeder basis with load appropriately sectionalized to other feeder(s) to serve all customers under peak load conditions.

The power flow analyses were performed for the conditions noted above to identify the system configuration voltage drops, load balance, real and reactive power flows, and system losses at system busses as labeled. The results are presented in Chapter 7 with detailed analysis output reports in the Appendix.

CAPACITY FOR FUTURE GROWTH, SYSTEM IMPROVEMENT RECOMMENDATIONS

Evaluate all analysis and evaluation results to determine if any portion of the system may not meet the planning criteria based on the stated assumptions for future load growth. Solutions and system improvements (immediate, intermediate and long-term), are recommended as necessary to mitigate possible system performance issues in the form of a prioritized work plan with budgetary cost estimates.

WRITTEN REPORT & PRESENTATION

This written report includes:

- Documentation of references, gathered data and sources, planning criteria, load forecasts, related calculations, analysis techniques and reports.
- System evaluation and analysis, identified strengths and weaknesses, including alternative improvements options, and suggested areas to focus attention.
- A list of conclusions, recommendations, and improvements, with construction schedules and budgetary cost estimates including multi-year cash flow breakdowns.
- Alternatives and options, system diagrams and models, and supporting information.
- System maps and analysis plots showing the configurations and results, system improvement maps, and tabulated schedules of prioritized recommended system improvements.

In addition to the written report, we will be providing a detailed presentation to the City's staff and an overview presentation to the City Council.

CHAPTER 2

EXECUTIVE SUMMARY

CHAPTER 2

EXECUTIVE SUMMARY

A. GENERAL

The City of Ashland owns and operates electric distribution facilities presently serving approximately 12,705 customers (meters). The City's electric service area is completely surrounded by the Pacific Power (PacifiCorp) Medford service area.

All electric power sold by the City of Ashland is provided by BPA, transmitted through PacifiCorp's 115 kV transmission system, and transformed from 115 kV to 12.47 kV at one BPA-owned substation (Mountain Avenue) and two PacifiCorp-owned substations (Ashland and Oak Knoll). Over the last 10 years, PacifiCorp has made significant improvements to the transmission system serving the City of Ashland. The City is now served from a looped 115 kV transmission system with multiple backup sources.

The City continues to have an exclusive power purchase agreement with Bonneville Power Administration (BPA). At Mountain Avenue Substation, the City pays BPA a Utility Delivery Charge (UDC) of $1.399 per kW per month for power delivery at 12.47 kV, based on the peak demand. BPA has a General Transfer Agreement (GTA) with PacifiCorp for use of their transmission and substation facilities, and the City pays $0.82 per kW per month for delivery at 12.47 kV at Ashland and Oak Knoll Substations. The UDC billing determinant is the average 60 minute demand at Mountain Avenue Substation on the hour of the BPA transmission usage peak, while the GTA billing determinant is the City's maximum 60 minute average demand period during the month at Ashland and Oak Knoll substations. Delivery charges, substation ownership, and transmission improvements are further discussed in Chapter 5.

There is a strong correlation between ambient temperature (high and low) and peak loading on the City's electric system. Evaluation of the City's electric system load data indicates that its recent peak (43.9 MW, December 2013) is close to the maximum historical peak (44.6 MW, December 1990). While the December 2013 peak occurred on a 1 in 10 year cold weather event, the historical peak in December 1990 happened during an even colder weather event that is statistically experienced approximately once every 25 years on average. The fact that this recent peak was nearly equal to the historic peak even though the temperature was less extreme indicates an underlying growth in peak demand within the City. This is consistent with the fact that the population, customer base, and energy use (kWh) of the City of Ashland has grown significantly between 1990 and 2013. Historical data, weather trends, and future system growth are further discussed in Chapter 3.

In the previous study, it was noted that "the City could expect that the summer peak demand may be equal to the winter peak demand around 2010 to 2012." As the data presented in Chapter 3 shows, the summer peak has equaled the winter peak multiple times since 2002. Summer peak demands should be carefully monitored because equipment ratings under summer conditions are less than equipment ratings under winter conditions due to the inherently higher ambient temperature in the summer.

Evaluation of the City's energy sales since the last study shows that annual energy usage grew 8.4% from 2002 to 2008. In 2009 and 2010 energy sales decreased significantly to levels not seen since 2001, but rebounded strongly from 2010 to 2013 to the point where energy sales in 2013 exceeded energy sales in 2008 (the previous largest year) by 0.5%. The recent return to year over year growth in energy usage means that there likely exists the potential for a new summer or winter peak on City circuits during extreme warm or cold weather events. Since electricity cannot be economically stored, the electrical system infrastructure must be adequately sized for the peak system loads.

Based on data and the assumptions used for this study, there is sufficient substation transformer and distribution system circuit capacity to serve the City's expected peak demand load through 2023 under normal operating conditions. However, the loss of any single major system component ("single-contingency" failure conditions) could result in reduction of the overall system capacity to below the historic peak demand. Single-contingency limitations and concerns are described in greater detail in Chapter 5 and Chapter 7.

The conclusions and recommendations throughout the remainder of this section are based on the overall goals of adequate substation capacity and a flexible distribution system available to reliably serve existing and future projected load.

B. MAJOR IMPROVEMENTS SINCE THE 2003 SYSTEM STUDY

In the 10 years since the previous study, several significant electric system changes took place that improved service and reliability to City customers. Major improvements are listed below:

TRANSMISSION

- After years of having a weak looped transmission system serving the three City substations, PacifiCorp upgraded the 69-kV source at Ashland Substation to 115-kV. This significantly increased the capacity from that source. Additionally, other PacifiCorp Medford regional area transmission system upgrades and reconfigurations enabled additional strong backup sources to the Ashland transmission loop.

SUBSTATIONS & GENERATION

- Mountain Avenue Substation: City-owned facilities at this substation were improved by expanding the distribution rack and adding three feeder positions, installing new microprocessor multifunctional circuit controllers for all 6 feeders in the Control Building, and implementing SCADA system capability. The City also installed a new microprocessor controller on the substation voltage regulator, added one new feeder circuit, and extended conduit outside the substation yard for two future feeder circuits.
- Ashland Substation: The City converted an existing City-owned building near this substation to a control facility and installed new microprocessor multifunctional circuit controllers for all 4 feeders. SCADA system capability was also implemented.
- Reeder Gulch Hydro: The City updated/replaced electric circuitry and control devices, modernizing protection, control and monitoring functions, and implemented SCADA

system capability. The City also cleaned out the lower intake, increasing power output, while adding provisions for easy future cleaning.

DISTRIBUTION SYSTEM

- Installation of a Supervisory Control and Data Acquisition (SCADA) System situated in the Electric Department dispatch center that has monitoring and control capability of all feeder circuits, field reclosers and capacitors, and the Reeder Gulch Hydro facility. This improvement offers the City the ability to monitor and document system performance in real time, identify and prevent potential problems, and assist with trouble-shooting when necessary.
- Created and implemented an Electric Service Requirements (ESR) manual to provide instructions on system interconnection and service construction standards to developers and contractors.
- Implemented Service Request Application Forms for developers and contractors.
- Performed an Arc Flash Hazard Assessment for major system equipment and throughout the electrical system in compliance with National Electric Safety Code (NESC) requirements.
- Created oil Spill Prevention, Control and Countermeasure (SPCC) plans with documented guidelines for the electrical storage yard, specific devices and locations. This was done in accordance with EPA 40 CFR, Part 112. In addition, the City has updated its specifications for the purchase of equipment containing oil.
- Implemented Distributed Generation Renewable Resource, Net Metering interconnection agreement, and purchase agreement policies.
- Implemented a Reliability Tracker program to provide annual reporting on the electric distribution systems performance based on industry standard criteria to statistically track outage frequencies and durations in accordance with IEEE 1366 Index Standards.
- Developed overhead conductor sag and tension calculations with construction stringing charts for multiple conductors and conditions based on NESC Zone 2 Loading District. The calculations included specific weather criteria to ensure consistent conductor installation standards.
- Developed up-to-date standards for consistent purchase of major electrical equipment.
- Developed employee training standards for substation and field equipment operation and maintenance.
- Improved system reliability by installing three new field sectionalizing devices with SCADA system interconnection.
- Improved local and system-wide power factor and voltage control by installing new field capacitor banks with smart switching controllers and SCADA system interconnection.
- Highway 66 circuit I-5 crossing: Installed self-supporting steel poles with new undergrounding circuit and cable risers east and west of the interstate highway.
- Crowson Road circuit I-5 crossing: Installed self-supporting steel poles with provision for future undergrounding circuit and cable riser terminations east and west of the interstate highway.
- The City has installed numerous self-supporting steel poles at various locations throughout the electric system to retire old wood poles and eliminate congested guy and anchor installation conditions.

- N. Main and Hersey Street intersection re-alignment: The City installed a new undergrounding circuit with self-supporting steel poles and cable risers east and west of the intersection.
- The City completed several underground conversions and cable replacements, strengthened circuit intertie connections and looped circuits to serve critical customers.
- The City has been implementing radio-read meters that telemeter customer usage data to a drive-by data acquisition system. Although installations have temporarily slowed due to radio frequency concerns, it is expected that the City will migrate toward smart meter installations, consistent with trends in the industry.
- The Railroad Feeder (A2002) has recently been re-conductored and now allows for a stronger backup source to/from the Morton Feeder (M3009).
- A recent conductor upgrade allows the hospital (a critical load) to be served from the Business Feeder. This strengthens the service to the area by providing a strong backup to the normal North Main Feeder source.

C. COMMENTS & RECOMMENDATIONS

As a general recommendation, the City should adopt the planning criteria and implement the system improvements as presented in this report and specifically in Table 2-1. Improvements should be made as necessary to serve the actual load economically, while at the same time meeting prudent service quality and reliability standards.

This report should be reviewed and updated approximately every two-to-five years to ensure that decisions regarding improvements are based on current system conditions. All new facilities should be constructed in accordance with the latest expansion plan to ensure that no facilities become obsolete early in their service lives.

Specific recommendations resulting from this study are intended to meet normal load growth requirements and resolve specific operating deficiencies. All cost estimates shown are in 2014 dollars and are based on work performed by a contractor after competitive bidding unless otherwise noted.

It should be noted that some of the recommended improvements are already in progress and other recommendations do not have a fixed cost associated with them. In some cases the work associated with the improvement would be performed by the City staff and line crew as part of their ongoing maintenance activities. In other cases the costs cannot be accurately determined until the scope of the improvement to be undertaken is refined.

TRANSMISSION

With the facility improvements made over the last 10 years, all normal transmission sources are now capable of serving the entire Ashland regional load into the long term future. The existing looped configuration and available backup transmission paths provide the City with adequate service integrity.

As the PacifiCorp transmission system is presently operating, a permanent fault on the 5.4 mile 115 kV Line 82 between the Ashland 115 kV breaker (2R266) and the Oak Knoll 115 kV breaker (2R262) would interrupt electric service to the entire City of Ashland for a short period of time while isolation switching was performed by PacifiCorp. To isolate a fault on this line, manual switching is required. While this operating arrangement is not unusual, it is a vulnerable point in the transmission system serving the City of Ashland. It is recommended that the City discuss this concern with PacifiCorp to see if there are any long-term plans for additional automatic sectionalizing on the 115 kV system.

SUBSTATIONS

As discussed in Chapter 7 and Chapter 3, sufficient substation capacity is currently available to serve the City's expected peak loads for the next 10 years under normal operating conditions. However, the loss of any single major system component under high load conditions can create the potential for overloading portions of the system and creating extended outages for City customers. The failure of a transformer at either Ashland or Mountain Avenue Substation during a peak load condition would create severe transformer overload conditions on the remaining substation transformers. Loss of Oak Knoll Bank #2 causes Bank #1 to be loaded to 99.7% of winter capacity. Additionally, due to its age and design, the City-owned distribution rack in Ashland Substation does not meet current safety standards for field access and operations, and is becoming prone to failure.

A prioritized list of recommended substation-related improvements and budgetary cost estimates can be found in Table 2-1. Major recommendations related to the substations serving the City include:

- Installation of new microprocessor relays, SCADA infrastructure, and sectionalizing equipment for the 3 feeders serving City circuits at Oak Knoll Substation.
- Purchase of Mountain Avenue Substation with mobile transformer backup agreement, and installation of a second transformer.
- Replacement the City-owned distribution rack in Ashland Substation with a new rack in the same location, or construction of a new City-owned substation near Ashland Substation.

DISTRIBUTION

Based on the projected peak for 2023, all City-owned distribution system components have sufficient capacity. The City has strengthened many feeder backbone conductors and feeder tie circuits over the last ten years and should be able to transfer all load from any one feeder to adjacent feeders. However, some sectionalizing schemes can result in heavily loaded backbone conductors and transformers. Transferring certain feeders at peak load will become problematic in the next ten years, particularly during summer peak loading, if load growth occurs as expected.

Recommended distribution system improvements are also listed in Table 2-1. Major recommendations related the distribution system include:

- Balance existing feeder loading.
- Reconfigure system to utilize extra feeders at Mountain Avenue Substation to help balance feeder loading.

- Replace old direct buried cable that has bare concentric neutral with new jacketed neutral cable.
- Reduce phase imbalance on specified feeders.

TABLE 2-1 -- Recommendations		
	Description	**Estimated Cost ($2014)**
General System		
G-1	If the City is successful with negotiations to purchase Mountain Avenue Substation it may want to consider installing an on-line gas-monitoring system on the existing power transformer to continuously monitor transformer health. Sensor capabilities vary widely, but could allow the City to monitor up to eight critical fault gases in addition to moisture. It can be installed while the unit remains in service and is field based, requiring no manual oil sampling or lab testing.	$5,000 Base unit $20,000 With Pump
G-2	In order to minimize downtime due to faults, many utilities now employ sets of automatic fault interrupting and sectionalizing switches throughout their systems. The City should evaluate the use of these devices for "self-healing" of the distribution system at key locations. Cost estimates provided include all equipment and installation costs per switch.	$46,000 Overhead Mount $127,000 Pad Mount
G-3	The electric distribution system includes some customers in PacifiCorp areas served by the City's system and some customers in the City's territory served by PacifiCorp. A long-term goal should be to adjust agreed-upon service territory boundaries or transfer these services to the appropriate utility. If no agreement is currently in place, one should be reached to ensure energy billing is accurate. The City may choose to install primary metering between these interconnections to get an indication of these tap loads.	$9,000-$12,000 3ϕ Pri. Meter $3,000-$4,000 1ϕ Pri. Meter $1,500-$2,500 UG Sec. Meter
Transmission System		
T-1	Open a discussion with PacifiCorp about enhancing the sectionalizing capability on the 5.4 mile 115 kV Line 82 between the Ashland 115 kV breaker (2R266) and the Oak Knoll 115 kV breaker (2R262).	NA
Substations		
S-1	Outside the PacifiCorp Oak Knoll Substation, install three separate pole-mounted reclosers (one for each feeder serving the City) with microprocessor controllers and SCADA infrastructure.	Underway

TABLE 2-1 -- Recommendations

	Description	Estimated Cost ($2014)
S-2	Resume negotiations with BPA to purchase Mountain Avenue Substation. The City's most recent offer was $1.29 million. BPA's most recent price was $1.645 million. Access to mobile substation should be secured for interim period before 2nd transformer is installed. In the long term, implement transformer differential protective relaying on the existing transformer for increased protection.	TBD
S-3	Add a second transformer at Mountain Avenue Substation. Estimated cost includes transformer, circuit switcher, voltage regulator, structures, foundations and ancillary facilities as necessary. Operations and maintenance costs not included in estimate.	$1,008,000
S-4A OR	The City should consider building a City-owned substation near PacifiCorp's Ashland substation to replace the City's existing distribution rack and allow for more operational flexibility and growth options. Operations and maintenance costs not included in estimate.	$1,200,000 (in addition to dist. Rack in S-4B)
S-4B	Replace the City-owned distribution rack in place at Ashland Substation or construct a new rack on City owned property across the street as a first step towards a future Nevada Street substation. Cost estimate is based on replacing rack in place with four feeder positions similar to the new rack at Mountain Avenue Substation.	Contractor Install: $380,000 City Install: $250,000
Distribution System		
D-1	On the East Main circuit (5R93) I-5 crossing, upgrade the existing overhead circuit wood pole construction to self-supporting steel pole construction.	Underway
D-2	As load increases, rebalance existing loads to reduce loading on the A2000, A2001, M3009, and 5R56 feeders. This would be done by transferring load to A2002, M3006, M3015, and 5R93 since these feeders are more lightly loaded. Some general suggestions are offered below: • Move 1-2 MW of load from A2000 to A2002. • Move 1 MW of load from M3009 to M3006. • Move 1-1.5 MW of load from 5R56 to 5R93.	Normal Maintenance Activity
D-3	The City should target 500-1000 feet of aging bare concentric neutral cable per year for replacement in addition to replacing segments as they fail. The bare neutral cables are known to corrode which leads to potential public safety issues as well as voltage problems due to loss of neutral return.	$100/ft $50,000-$100,000

TABLE 2-1 -- Recommendations

	Description	Estimated Cost ($2014)
D-4	Transfer 3 MW of peak load from Ashland Substation North Main Feeder (A2001) to an unused or new feeder out of either Ashland or Mountain Avenue Substation. Final action dependent on rate of load growth on A2001 and the City's future actions with respect to substation ownership and expansion.	TBD
D-5	We recommend that phase imbalance on all feeders be monitored under peak load conditions. If imbalance on the listed feeders continues to exceed 15%, action should be taken to shift load and reduce imbalance to below 10%. Using recent data, phase imbalance was found to be greater than 15% on feeders A2000, A2001, M3015, 5R56, and 5R93.	As Needed
D-6	For underground facilities, fused elbow connectors in vaults or at equipment helps to isolate circuit taps and minimize the number of customers experiencing interruptions or outages. The City should consider installation of fused loadbreak elbows at backbone circuit major tap locations which are presently not sectionalized.	Underway $325 per Elbow $225 per Fuse
D-7	As load growth occurs and additional transformation capacity is added at Mountain Avenue Substation, the City should construct the two available feeders at Mountain Avenue Substation. Cost assumes each feeder constructed underground at $100/ft. for all material/labor.	$50,000 (each fdr)
D-8	The City should continue the practice of logging outage information in the recently implemented eReliability Tracker program.	Underway ($149/yr)
D-9	The City should complete a set of standard Construction Unit Drawings for consistent application of construction practices and materials.	$15,000-$25,000
D-10	Continue to add overhead and underground fault indicators on feeder main backbones to assist in location of faults.	$100 each (includes installation)

CHAPTER 3

LOAD FORECAST

CHAPTER 3

LOAD FORECAST

This chapter describes a load forecast developed for the City of Ashland based on the peak system demand expected for a 1 in 10 year warm or cold weather event. Included are five-year and ten-year projections covering the period from 2013 to 2023, based on BPA and Ashland meter data as well as data and projections provided by the following sources:

- The City of Ashland Comprehensive Plan
- The City of Ashland Buildable Lands Inventory
- The Jackson County Comprehensive Plan
- The Oregon Office of Economic Analysis (OEA)
- Portland State University Population Research Center
- BPA
- PacifiCorp
- United States Census Data
- The Public Utility Commission of Oregon
- The Oregon Climate Service

While meter data from 1994 to 2013 was analyzed, the load forecast projections and assumptions are based on the period from 2003 through 2013. Fifty years of climate data were used for the analysis. As established in previous studies, there is still a strong correlation between temperature and system power demand for both warm and cold temperatures.

A. HISTORICAL OPERATING CONDITIONS

The City of Ashland's historical maximum system peak, 44.6 MW, occurred December of 1990. Steady increases in energy use and population growth leading up to 2008 correlate with summer and winter peak demands now consistently reaching 40 MW. The highest recent system peak was 43.49 MW and occurred in December of 2013.

Table 3-1 lists the City's peak demand, energy use and population growth for the period from 2003 through 2013. The steady growth experienced in the 1990's continued until approximately 2008 after which both population and energy consumption fell significantly. A pattern of energy and population growth has emerged since 2010, and in 2013 the population of Ashland was close to what it was in 2003.

Table 3-1

Population Growth, Energy Use, and Peak Demand

Year	Peak (MW)	Energy (kWh)	Population
2003	37.97	171,920,100	20430
2004	38.33	175,293,480	20590
2005	38.69	178,064,595	20880
2006	39.07	180,419,455	20974
2007	39.43	182,696,625	21062
2008	39.80	184,296,170	20782
2009	40.16	177,741,226	20996
2010	40.53	168,980,735	20078
2011	40.88	176,722,735	20255
2012	41.26	179,815,430	20325
2013	43.49	185,231,385	20295

Although the recession and its abrupt effects on population and energy use make the trend complicated, the rate of change of population and energy-use is still best approximated as one-to-one. This observation is based on the data presented in Table 3-1, as well as Figures 3-1 and 3-2 which show the City's historical population, energy use, and yearly rates of change, respectively. For the load forecast in this study, we will continue to assume that the City's energy-use and potential peak demand will increase at the same rate as population growth.

The City's electric system coincidental monthly peak demands for the period of 2003-2013 are shown in Figure 3-3 and Table 3-2. The City's peak demand is characterized by summer and winter peaks of nearly the same magnitude.

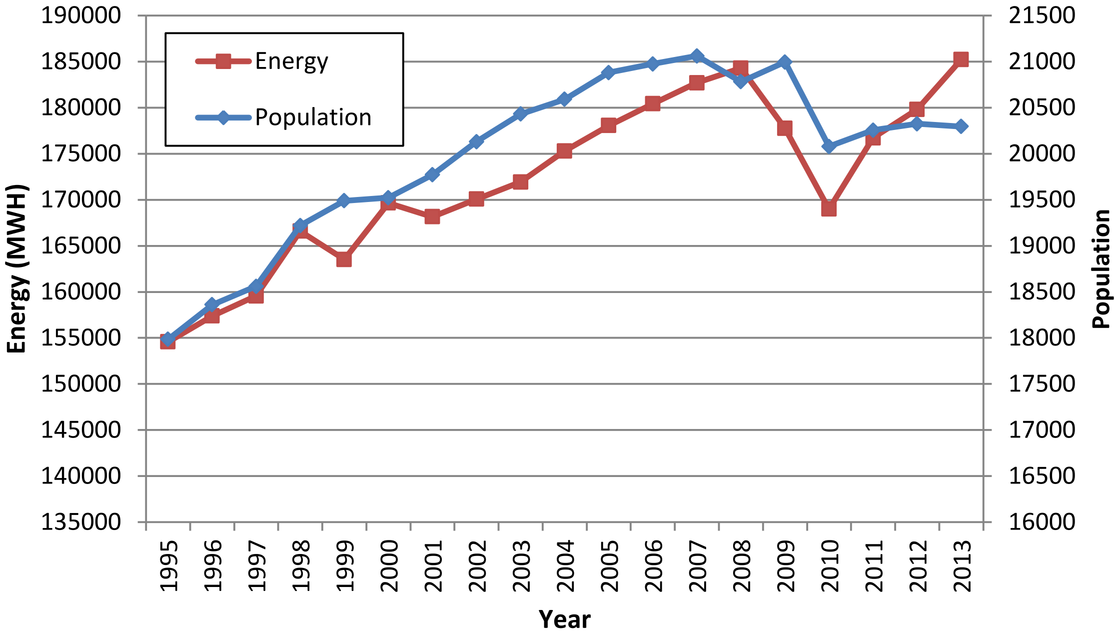

Figure 3-1: Total annual energy use (MWH) and population growth.

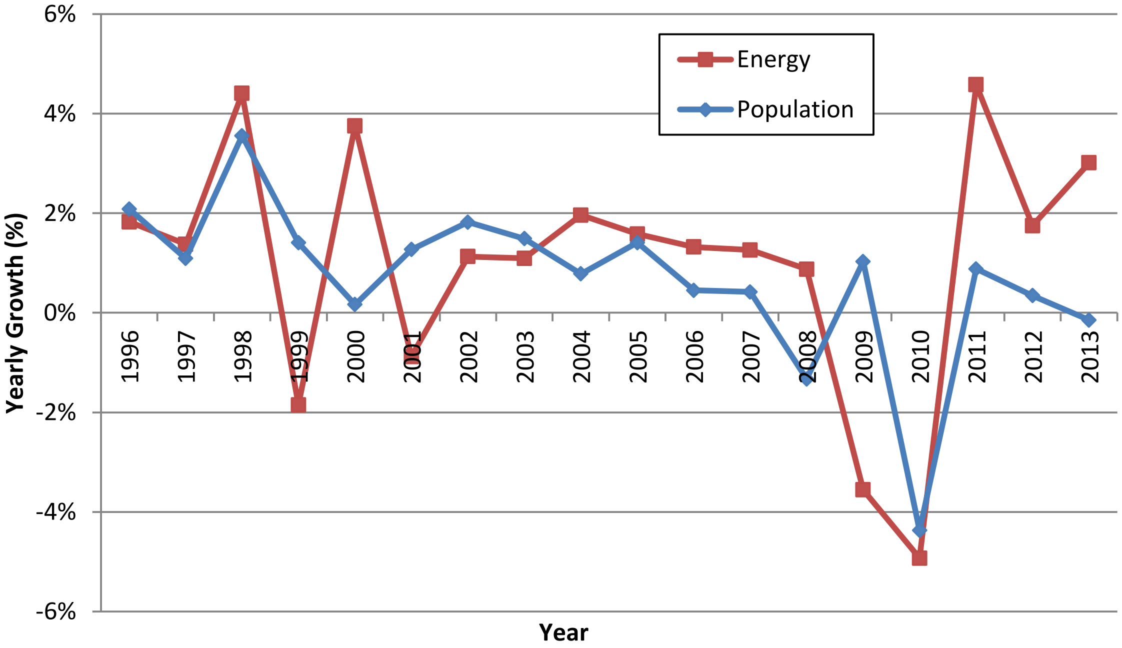

Figure 3-2: Total annual energy use (MWH) and population, yearly rates of growth.

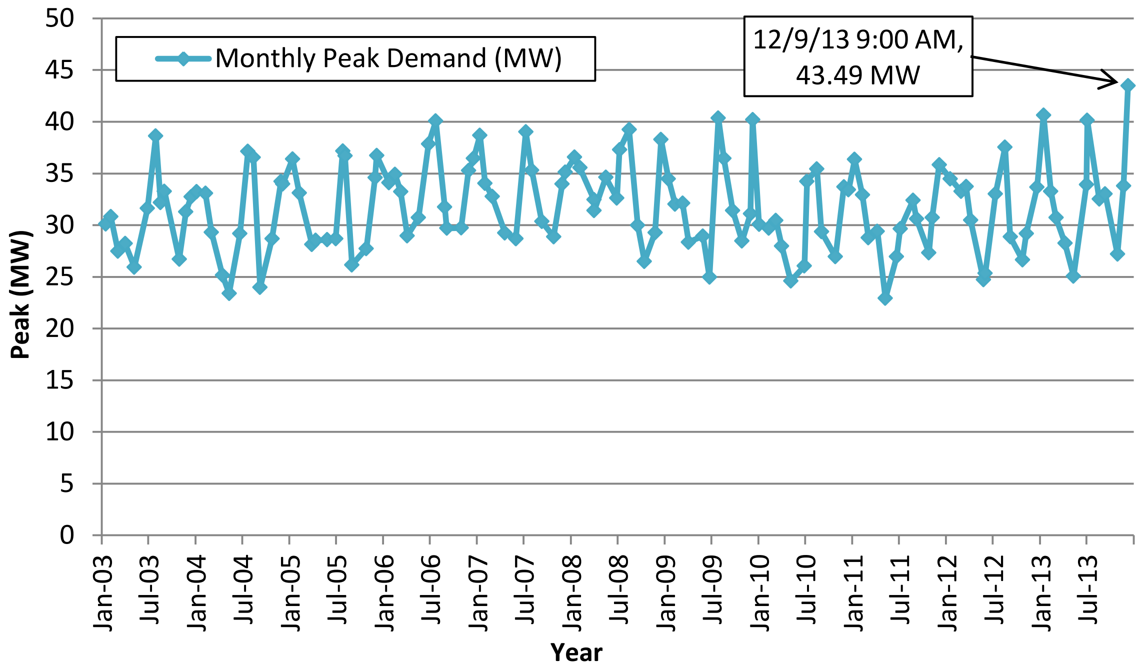

Figure 3-3: Monthly peak demand.

Table 3-2
City of Ashland - Monthly Peak (MW)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
January	30.1	33.2	36.4	34.1	38.7	36.6	34.5	30.1	36.4	34.5	40.7
February	30.8	33.1	33.1	34.9	34.1	35.6	32.0	29.7	32.9	33.3	33.3
March	27.5	29.3	28.1	33.2	32.8	32.5	32.1	30.5	28.8	33.7	30.7
April	28.2	25.2	28.5	29.0	29.3	31.4	28.4	28.0	29.4	30.5	28.2
May	25.9	23.4	28.6	30.7	28.7	34.6	29.0	24.6	22.9	24.7	25.1
June	31.6	29.2	28.7	37.8	28.7	32.6	25.0	26.1	26.9	25.3	33.9
July	38.6	37.2	37.2	40.1	39.0	37.3	40.4	34.2	29.6	33.0	40.1
August	32.2	36.6	36.7	31.7	35.3	39.2	36.5	35.4	32.4	37.6	32.5
September	33.3	24.0	26.2	29.7	30.4	30.0	31.4	29.4	30.6	28.9	33.0
October	26.7	28.7	27.7	29.7	28.9	26.5	28.5	27.0	27.3	26.6	27.2
November	31.3	34.2	34.6	35.3	34.0	29.3	31.1	33.7	30.7	29.2	33.8
December	32.7	34.0	36.7	36.5	35.1	38.3	40.2	33.4	35.8	33.7	43.5
Average	30.8	30.7	31.9	33.6	32.9	33.7	32.4	30.2	30.3	30.9	33.5
Summer Avg.	35.4	36.9	36.9	35.9	37.2	38.3	38.4	34.8	31.0	35.3	36.3
Winter Avg.	32.0	33.0	35.2	35.4	37.6	35.9	36.4	35.1	34.9	35.2	37.2

Notes: Summer average includes months of July and August.
Winter average includes consecutive months of December and January (e.g., 2004 Winter Avg. includes Dec. '04 and Jan. '03).

B. WEATHER-RELATED CONSIDERATIONS

In order to examine the effect of weather on system peak demand and energy use, we obtained Oregon Climate Service data from the Ashland weather station for 1963-2013. Analysis of the data for this period yields statistical 1 in 10 year cold and warm weather events of approximately 8 degrees F and 105 degrees F.

Figures 3-4 and 3-5 show the annual *heating degree days* (HDD's) and cooling degree days (CDD's), respectively, for 2003-2013 against the 1981-2010 and 2003-2013 averages. HDD and CDD are measurements, based on outside air temperature, that are designed to reflect the demand for energy needed provide heat or cooling for a building or home for every degree above or below 65 degrees F. The data show that in the recent 10-year period, it was slightly colder in the winter and warmer in the summer than in the past 30 years.

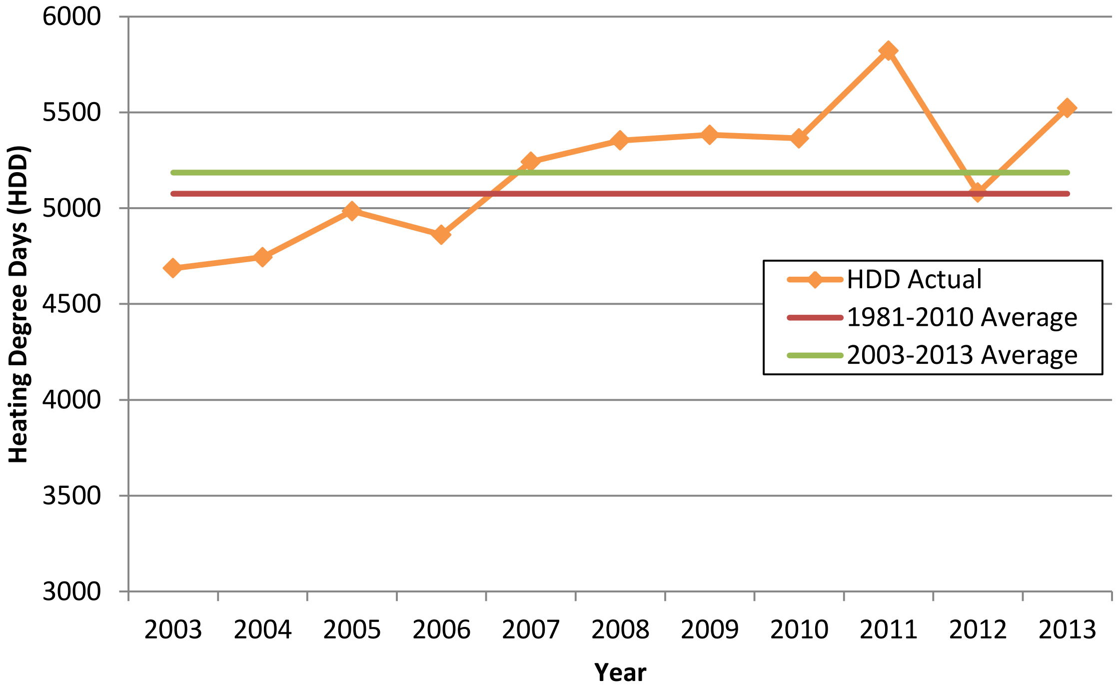

Figure 3-4: Heating degree days at Ashland weather station shown with long term averages.

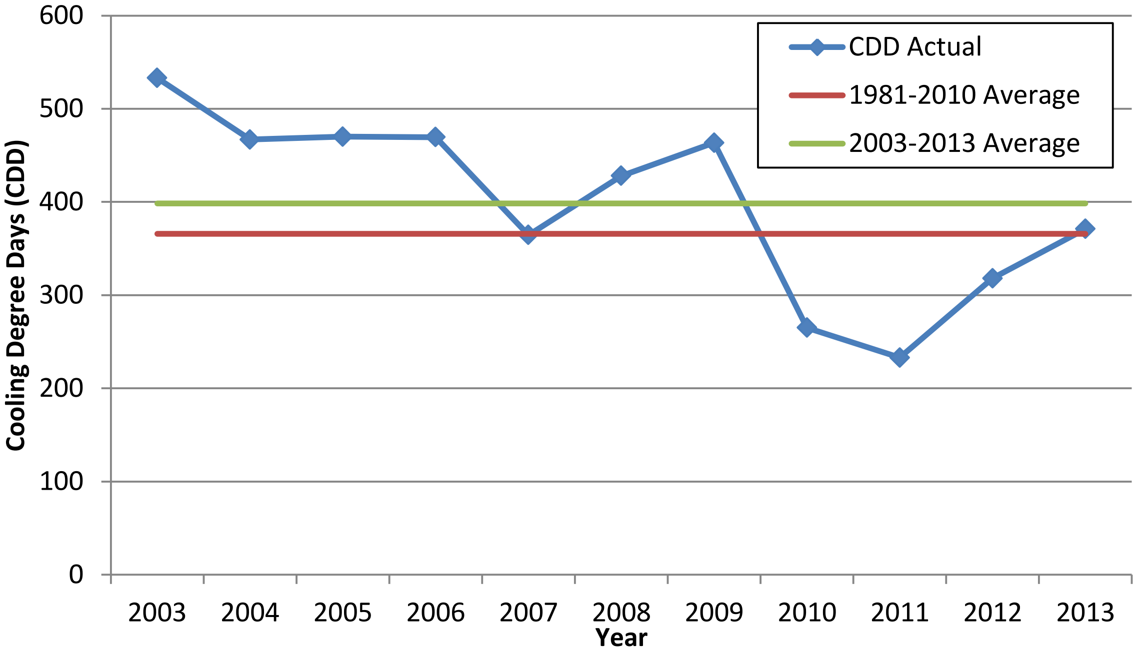

Figure 3-5: Cooling degree days at Ashland weather station shown with long term averages.

Figure 3-6 shows the monthly mean demand for the City of Ashland plotted with the monthly mean temperature for 2003-2013. As noted in the previous study, there is a strong correlation between temperature and system power demand for both warm and cold temperatures. While less energy is used during the summer, Figure 3-3 shows that the summer peak demand is frequently at the same level as winter peak demand.

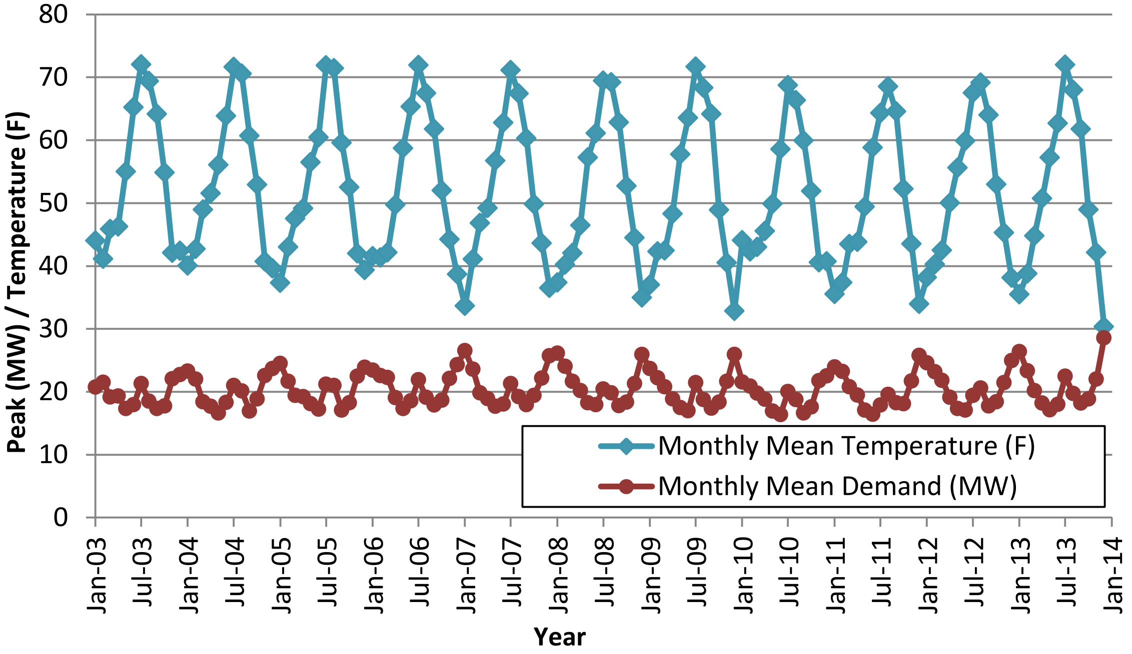

Figure 3-6: Monthly mean temperature and monthly mean demand.

Tables 3-3 and 3-4 show the three highest summer and winter peaks for 1998-2013 with correlated temperatures. It is reasonable to conservatively assume that if a 1 in 10 year warm weather event (105 deg. F) occurred in 2013 or 2014, the resulting peak demand would be similar in magnitude to the 43.49 MW cold weather peak experienced on December 9, 2013. The recent December 2013 peak will be used as the base case for the 5 and 10 year peak load growth projections.

Table 3-3
Highest Winter Peaks and Correlated Temperatures

Date	Peak (MW)	Temperature (F)
12/9/13 9:00 AM	43.49	8
12/22/98 9:00 AM	42.13	1
1/14/13 9:00 AM	40.65	13

Table 3-4
Highest Summer Peaks and Correlated Temperatures

Date	Peak (MW)	Temperature (F)
7/28/09 5:00 PM	40.35	105
7/3/13 5:00 PM	40.13	100
7/24/06 5:00 PM	40.075	102

C. GROWTH FORECASTS

The BPA annual peak forecast for the Ashland area is presented in Table 3-5 alongside the City of Ashland Peak Demand Forecast determined in this study.

Table 3-5
PacifiCorp, BPA, and City Load Forecasts (2013-2023)

Year	BPA Forecast (MW)	City of Ashland Peak Demand Forecast (MW)
2013*	**43.49**	**43.49**
2014	37.20	43.95
2015	37.38	44.42
2016	37.57	44.89
2017	37.76	45.36
2018	37.95	45.84
2019	38.14	46.33
2020	38.33	46.82
2021	38.52	47.32
2022	38.71	47.82
2023	38.90	48.33

* Actual data used for 2013.

The BPA forecast is based on a growth rate of 0.5% for the entire planning horizon. This growth rate is reasonable, but it must be noted that the BPA forecast uses a 1 in 2 year weather event as its planning criteria. By design, this results in peak demand estimates that do not account for the possibility of extreme cold or warm weather events. The actual 2013 Ashland system peak was significantly higher than the BPA forecast for 2023.

PacifiCorp also provided a growth forecast for its Ashland Facilities for the 2014-2023 period which calls for zero growth through 2018 followed by an average annual growth rate of approximately 2.4% for the 2018 through 2023 period. According to PacifiCorp staff, this forecast is based simply on what they see the historical healthy growth rate to be (2.4%) and when they expect the City of Ashland to return to that healthy growth rate (2018). The end result for 2023 is similar to the City of Ashland Peak Demand Forecast, but the PacifiCorp forecast is not based on a detailed analysis of population and economic trends.

Consistent with the 2003 system planning study, it is recommended that the City should base its system planning on a minimum of at least a 1 in 10 weather criteria. The City of Ashland Peak Demand Forecast in Table 3-5 is based on this criteria and a growth rate of 1.06%. This growth rate is consistent with data provided by the City of Ashland and Jackson County planning departments. Since the City must be able to serve all customers reliably at peak load, system planning and design requirements should incorporate the City of Ashland Peak Demand Forecast.

Figure 3-7 shows the historic yearly peak winter and summer demand with Ashland and BPA forecasts in context of the Ashland available transformation capacity under different system configurations. The available Ashland transformation capacity decreases slowly starting in 2014 due to PacifiCorp loads (at Ashland and Oak Knoll Substations) growing at the same rate as the rest of the system.

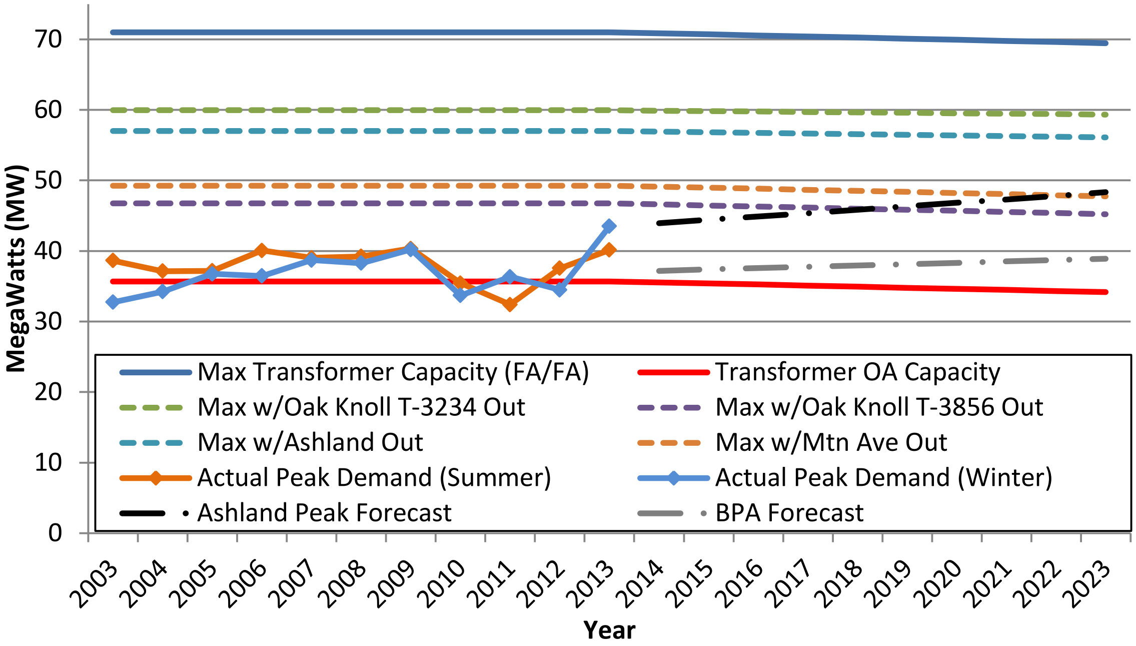

Figure 3-7: Peak demand data, projections, and transformation capacity available to the City.

D. CONCLUSIONS

The recommended improvements and improvement schedule used in this study are based on the system peak demand calculations summarized in Table 3-6. These demands were determined using a population growth rate of 1.06% provided by the City of Ashland and Jackson County using the recent 2013 system peak of 43.49 MW as a base value. The schedule of improvements should be evaluated annually and modified as needed to correspond with actual growth and peak demand as load develops.

Table 3-6

Study Load Forecast Summary

2013 Actual Peak Load (MW)	2018 Peak Load (MW)	2023 Peak Load (MW)
43.49	45.84	48.33

CHAPTER 4

SYSTEM PLANNING CRITERIA

CHAPTER 4

SYSTEM PLANNING CRITERIA

A. GENERAL

As part of the planning study, specific guidelines and planning criteria were developed and tailored to the City of Ashland electric system and service objectives. Many of the criteria discussed below were established in the previous electric system planning study and are based on factors which affect system operations and maintenance, these include:

- Providing dependable and economic electric service to ratepayers while giving strong attention to public and personal safety.
- The planning, construction and operating practices of comparable electric utilities.
- The risk taken by following less stringent planning practices.
- The development of transmission and substation criteria so that in the future the City may take ownership, operate, and maintain such facilities.

B. SYSTEM LOADING

The City of Ashland experienced steady growth from the mid-1990s through approximately 2008 when both population and energy consumption decreased, as seen in Table 3-1. With the beginning of a recovery in recent years, local and regional planning entities project the population of the City of Ashland to increase throughout the planning period at an average annual rate of approximately 1.06%. An in-depth discussion of population and load growth is presented in Chapter 3 and specific areas of growth are presented in Chapter 7.

Prudent utility practice requires that system improvements be implemented prior to load growth to allow the utility to meet customer service demand. On the other hand, existing facilities should be utilized to the maximum practical extent to avoid costly premature construction of new facilities. Therefore, the recommended improvements in this report should be made as needed based on the best available growth data. The time frame of improvement implementation should be adjusted if the actual load growth varies significantly from the load forecasts, but with sufficient time allowed for necessary engineering, permitting, material procurement and construction.

C. SYSTEM RELIABILITY

A primary consideration in system planning is reliability. As of the last study, the City adopted a single-contingency reliability criterion and this approach should be continued. Single-contingency reliability is achieved when an outage of any single major component of the electrical system (transmission or distribution line, substation transformer, protective device, cable segment, switching component, etc.) results in only minor service interruption to a limited number of customers while allowing the utility to meet expected peak demand.

To meet this objective, and provide acceptable service continuity to the extent practical, the following criteria and recommendations should be used in planning and operating the electric system:

CRITERIA:

- Substations should have at least one alternate transmission line source (looped).
- Transmission line sections should be capable of being removed from service for maintenance without causing customer service interruptions.
- Single substation transformer outages should not cause prolonged customer service interruptions.
- The City should continue the practice of updating distribution circuit sectionalizing schemes. These schemes should allow for the transfer of load in case of the loss of any individual feeder or substation.
- Distribution feeders should be designed to be loaded to a maximum of approximately 7.5-MW during normal operation and temporary loading up to 11-MW during planned maintenance or emergency system outages with load transfers.
- Each distribution feeder should be capable of being supplied by one or more alternate distribution sources through group-operated, load-break switching devices installed at appropriate system locations. This will allow circuit breakers or reclosers and other feeder components to be taken out of service while maintenance is performed without causing lengthy customer service interruptions.

RECOMMENDATIONS:

- The City should have a documented emergency load curtailment plan that identifies probable load shedding schemes, critical loads, and establishes load restoration plans.
- The City should perform periodic maintenance testing of all major electrical equipment in accordance with NETA guidelines.
- The City should confirm and document that power providers have arrangements for substation emergency backup during failure or planned maintenance through use of mobile transformers or other means to ensure power delivery.
- When feeder circuits are connected to two separate substation transformers (parallel operation or hot-transfer), load sharing between the two transformers will generally not be equal due to variations in the transformer impedance and line characteristic impedances. When opening feeder tie switches considerable current and voltage can exist across the switch. It is recommended that, to the extent possible, all tie switching involving connection and disconnection of two energized transformers be done via three-pole group-operated switches, preferably with load-break capability.

- During situations when PacifiCorp has substations served by different transmission systems, parallel operation or hot-transfer of feeders from the two substations served under this configuration should be avoided to prevent a condition of elevated fault current available at the tie point of the two sources. If the City determines it is absolutely necessary to parallel operation from two transmission systems it must first be confirmed that the two transmission systems are synchronized and transmission operators are notified. Additionally, since voltage angles might not match exactly between transmissions sources, load should be monitored at each substation to verify that circulating current does not exist on the distribution system.

- The City should continue the practice of reviewing and updating the coordination of protective devices as needed to ensure proper protection of system components and to minimize the impact of faults and disturbances on adjacent portions of the system.

- In addition to normal maintenance activities, The City should continue the practice of implementing specific preventive maintenance programs for major equipment.

D. SYSTEM DESIGN

The design of new facilities should be based on the following criteria and recommendations:

CRITERIA:

- The City should continue using the standard distribution conductor sizes selected in the previous electric planning study. The conductor selections and characteristics are presented in Tables 4-1, 4-2, 4-3, and 4-4A, B, C and D, shown below. The ampacities listed in these tables show that the distribution backbone conductors are capable of supporting greater loading than the design criteria, allowing for some reserve capacity.

  The design criteria philosophy is to allow any feeder to carry approximately two-thirds of an adjacent feeder's load in case of the loss of the adjacent feeder.

Table 4-1
Overhead Conductors

Voltage	Conductor	Circuit Application
12.47/7.2-KV	556.5-kcmil AAC	Distribution Main Backbones
12.47/7.2-kV	336.4-kcmil AAC and 4/0-AAC	Distribution Large Taps
12.47/7.2-kV	1/0 AAC and #2 AAC	Distribution Small Taps

Table 4-2
Underground Conductors

Voltage	Conductor	Circuit Application
12.47/7.2-kV	750-kcmil AL	Distribution Main Backbones
12.47/7.2-kV	500-kcmil AL and 4/0-AL	Distribution Large Taps
12.47/7.2-kV	#1/0-AL and #2-AL	Distribution Small Taps

The maximum ampacity rating and relative MW capacity for winter and summer loading for typical overhead and underground conductors and the City's standard conductor sizes are shown in Tables 4-3 and 4-4 below:

Table 4-3
Capacity Of Overhead Conductors

OVERHEAD CONDUCTORS						
Conductor			Winter (b)		Summer (b)	
Copper	ACSR	AAC	Ampacity	MW (c)	Ampacity	MW (c)
#6			165	3.46	115	2.41
#4			225	4.71	155	3.25
	#4		170	3.56	120	2.51
		#4	165	3.46	115	2.41
#2			290	6.08	200	4.19
	#2		225	4.71	155	3.25
		#2	220	4.61	150	3.14
	#1/0		295	6.18	205	4.29
		#1/0	300	6.29	205	4.29
	#2/0		345	7.23	240	5.03
		#2/0	345	7.23	240	5.03
	#4/0		450	9.43	310	6.49
		#4/0	465	9.74	320	6.70
	336.4		670	14.04	465	9.74
		336.4	630	13.20	435	9.11
	556.5		925	19.38	640	13.41
		556.5	870	18.23	600	12.57

a) Based on 75 Celsius (degrees) conductor temperature, 0 Celsius (degrees) Winter Ambient, 40 Celsius (degrees) Summer Ambient.

b) Electric Transmission and Distributions Reference Book, Westinghouse Electric Corporation, Pg. 48, Figures 25 and 26.

c) All MW ratings assume a three-phase system with 97% power factor.

TABLE 4-4A
Underground Cable Capacity 7.2 kV, EPR 133%, Full Concentric (a)

Conductor	In Duct Bank (b)		Direct Buried (b)	
	One Circuit (Amps)	MW (c)	(Amps)	MW (c) (1-Phase)
#2 AL	130	0.91	180	1.23
#1/0 AL	170	1.19	235	1.64
#2/0 AL	200	1.40	270	1.89
#4/0 AL	260	1.82	350	2.44

a) Based on Okonite URO-J literature for ***ONE*** single-phase circuit, one conductor in one conduit, with 105 deg C, 220 mil, 133% EPR insulation level with full concentric neutral.
b) 105 C conductor temperature, RHO = 90, 20 Celsius (degrees) ambient earth temperature, 100% load factor (applicable both summer and winter loading).

c) All MW ratings assume a single-phase system with 97% power factor.

TABLE 4-4B
Underground Cable Capacity 15 kV, EPR 133%, 1/3 Concentric (a)

Conductor	In Duct Bank (b)	
	One Circuit (Amps)	MW (c) (3-Phase)
#4/0 AL	245	5.13
500 kcmil AL	400	8.38
750 kcmil AL	490	10.27

a) Based on AIEE-ICEA Power Cable Ampacity Ratings, Volume I and II and Okonite URO-J literature for ***ONE*** three-phase circuit, three conductors in one conduit, with 105 deg C, 220 mil, 133% EPR insulation level with 1/3 concentric neutral. Derating is required for multiple circuits in a single duct bank.
b) 105 C conductor temperature, RHO = 90, 20 Celsius (degrees) ambient earth temperature, 100% load factor (applicable both summer and winter loading).

c) All MW ratings assume a three-phase system with 97% power factor.

TABLE 4-4C
Underground Cable Capacity – TWO Circuit Duct Bank (a)

Conductor	In Duct Bank (b)	
	Two Circuit (Amps)	MW (c) (3-Phase)
#4/0 AL	222	4.65
500 kcmil AL	357	7.48
750 kcmil AL	438	9.18

a) Based on AIEE-ICEA Power Cable Ampacity Ratings, Volume I and II and Okonite URO-J literature for ***TWO*** three-phase circuit, three conductors in each conduit, with 105 deg C, 220 mil, 133% EPR insulation level with 1/3 concentric neutral
b) 105 C conductor temperature, RHO = 90, 20 Celsius (degrees) ambient earth temperature, 100% load factor (applicable both summer and winter loading).

c) All MW ratings assume a three-phase system with 97% power factor.

TABLE 4-4D
Underground Cable Capacity – FOUR Circuit Duct Bank (a)

Conductor	In Duct Bank (b)	
	Two Circuit (Amps)	MW (c) (3-Phase)
500 kcmil AL	294	6.16
750 kcmil AL	359	7.52

a) Based on AIEE-ICEA Power Cable Ampacity Ratings, Volume I and II and Okonite URO-J literature for ***FOUR*** three-phase circuit, three conductors in each conduit, with 105 deg C, 220 mil, 133% EPR insulation level with 1/3 concentric neutral

b) 105 C conductor temperature, RHO = 90, 20 Celsius (degrees) ambient earth temperature, 100% load factor (applicable both summer and winter loading).

c) All MW ratings assume a three-phase system with 97% power factor.

- New substations or substation expansions should be located near areas where load growth is expected to occur. This will allow capacity to be efficiently utilized.

- Phase load imbalance on distribution feeders should be minimized to avoid overloading individual phases and reduce the need to oversize feeder backbone and tap conductors. If the imbalance on any feeder exceeds 15% during high load conditions, loads should be shifted between phases to reduce imbalance to 10% or below. This practice will help minimize neutral current and reduce neutral-to-ground potential.

- Substation main regulated bus voltage should be maintained in a range of 122-volt to 126-volt on a 120-volt base. Acceptable voltage standards and ranges are presented in Table 6-7 appearing in Chapter 6, Distribution System Evaluation.

- Voltage regulator settings should include first-house protection limiting the voltage to 126-volt maximum, and line drop compensation settings established to take into account line characteristic parameters.

- During high load conditions, the capacity of voltage regulators can be increased by programming the regulator controller to limit the maximum voltage adjustment range from the normal +/-10% to a lesser range. This allows the regulator to carry greater load (current), known as the so-called “load bonus” capability of most regulator controls. The capabilities for “load bonus” operation are dependent on the specific regulators and associated regulator controllers.

- Future substations should standardize on 15/20/25-MVA or 20/26.7/33.3-MVA, 115-12.47/7.2-kV, with four or five feeder bay capacity. Substation improvement planning should begin when peak loading reaches the existing substation facilities’ self-cooled transformer ratings, and if continued growth is expected to occur.

RECOMMENDATIONS:

- The implementation of self-healing load-transfer smart switches at key locations within the distribution system should be considered as a long-term goal to increase system reliability and uninterrupted service.

- The City should continue the practice of updating the geographic information mapping system so it can serve as a readily available component inventory and database.

CAPACITOR BANKS

- Capacitor banks should be used to maintain power factors between 97 to 99 percent lagging at peak load to avoid reactive power charges.

- First preference for the location of capacitor banks should be at the customer's site, especially at industrial installations.

- Total installed fixed capacitor bank installations should be limited to avoid an excessive leading power factor during low load conditions.

- The difference in total kVAR of capacitors required and the kVAR of fixed capacitors represents the kVAR of suitable automatically-switched capacitors.

- When installing or replacing capacitors the following guidelines should be observed:

    - Larger capacitor banks are typically more economical per kVAR than smaller banks, and it is generally best to avoid the use of capacitor banks less than 300 kVAR if possible.
    - Care should be exercised in sizing and locating switched capacitors so that the maximum primary voltage flicker does not exceed 3 volts (120 volt base) during normal capacitor switching.
    - Capacitors should not be installed on the load side of single-phase sectionalizing devices, as distorted or resonant voltage conditions may result from single-phasing.
    - Fixed capacitor banks should be manually switched seasonally as necessary to avoid excessive leading power factors during summer months.

CHAPTER 5

TRANSMISSION & SUBSTATION PLANNING

CHAPTER 5

TRANSMISSION & SUBSTATION PLANNING

A. TRANSMISSION SYSTEM

EXISTING SYSTEM

The City of Ashland's distribution service area is located within PacifiCorp's Medford service territory with power delivered to the City over the PacifiCorp transmission system. Since the last study, PacifiCorp has completed the following upgrades to the Medford region transmission facilities (refer to Figures B-1 and B-2 in Appendix B for an up-to-date transmission map of the region):

- Baldy Switching Station has been rebuilt to include a ring bus with three 115 kV circuit breakers. Transfer trip relaying has been installed, protecting each of the three transmission lines connected to the station. This improves the sectionalizing capabilities of the transmission system serving the City and should increase service reliability.
- The former 69 kV transmission line from Ashland Substation to Belknap Substation has been partially reconductored, converted to 115 kV and connected to the existing 115 kV Line 74 at Voorhies Crossing. This improvement provides a substantially higher capacity path to Ashland Substation via Talent Substation.
- A 115 kV circuit breaker has been installed at Ashland Substation on the line from Talent to Ashland.
- Four transmission switches have been constructed at Voorhies Crossing to supply the 115 kV line to Talent and Belknap Substations.
- The normal transmission source for the City of Ashland is now through Baldy Switching Station, Voorhies Crossing, and Talent Substation. The new alternate source provided by this connection is through Sage Road Substation.
- The transmission protective relaying at Sage Road, Copco2 and Lone Pine Substations has been replaced in order to provide transfer trip coordination with new breakers at Baldy Switching Station and Ashland Substation.
- The voltage controllers on two 230-115 kV transformer load tap changers at Lone Pine Substation have been replaced to improve 115 kV bus voltage regulation.
- Two 250 MVA 230-115 kV transformers have been installed at Copco2 Substation in place of a single existing 125 MVA transformer.
- The 69/115 kV auto-transformer at Ashland Substation has been moved to Belknap Substation.

Since mid-2013, the City of Ashland's normal transmission supply has originated from the Lone Pine Substation Line 19 South (breaker 2R1). At the new Baldy Switching Station ring bus, Line 74 is tapped off of Line 19 and continues through Campbell Substation to Line 3 at Voorhies Crossing which passes through Talent Substation to Ashland Substation. After being tapped at

Baldy Switching Station, Line 19 provides a transmission path to Copco2 Substation. Line 19 is tapped between PacifiCorp's Green Springs Generation facility and Baldy Switching station, becoming PacifiCorp Line 82 providing service to the PacifiCorp Oak Knoll Substation. Line 82 is looped in-and-out of the Oak Knoll Substation and continues to PacifiCorp's Ashland Substation. Between the Oak Knoll and Ashland Substations Line 82 is also tapped to serve Bonneville Power Administration's (BPA) Mountain Avenue Substation over a short 0.81 mile radial circuit owned by BPA.

The normal 115 kV transmission source via Line 19 South, Baldy Switching Station, Line 74, Voorhies Crossing, and Line 3 has a combined length of approximately 19.6 miles. The other side of the loop from Line 19 South through Baldy Switching Station and Line 82 to Oak Knoll Substation has a combined length of 18.52 miles. The 115 kV Line 19 tap (breaker 2R1) that serves as the loop's normal source is fed from the north through the PacifiCorp Dixonville, Meridian, and Lone Pine Substations. However, the loop can also be fed from the south via the Copco2 Substation. Another alternate transmission path exists through Sage Road, Jacksonville, and Griffin Creek Substations on Line 74 to Voorhies Crossing.

Breaker 3R1 at Lone Pine, which previously served the Ashland substation at 69 kV, now serves only the Foothills Road and Belknap Substations on Line 79. Additionally, there are normally open points between Voorhies Crossing and Griffin Creek Substations, as well as between the Line 82 tap and Copco2 substation.

The rated summer capacity for each normal and alternate source is listed in Table 5-1, based on information provided by PacifiCorp. Winter ratings are higher. According to PacifiCorp, the Sage Road Backup Source may have limited capability to supply Ashland-Oak Knoll at summer peak due to other system load. All other sources should have sufficient capacity to serve current and future peak winter and summer loads into the long term future.

Table 5-1
Transmission Source Continuous Rating

Source Name	Description	Summer Rating (MVA)
Normal Source to Ashland Substation	Line 19 South → Baldy Switching → Line 74 → Voorhies Crossing → Line 3 → Talent Substation → Ashland Substation	116
Normal Source to Oak Knoll Substation	Line 19 South → Baldy Switching → Line 19 → Line 82 → Oak Knoll Substation	97
Copco2 Backup Source	Copco2 → Baldy Switching → Ashland transmission loop	110
Sage Road Backup Source	Sage Road → Jacksonville → Griffin Creek → Voorhies Crossing → Ashland transmission loop	101

PACIFICORP AND BPA PLANS

BPA has no major modifications currently planned that would involve the transmission system serving the Ashland area. PacifiCorp planned improvements include:

- Add a 115 kV circuit breaker at Oak Knoll Substation on the 115 kV supply from Baldy Switching Station via the Oak Knoll Line 82 tap. Install transfer trip relaying to coordinate with the Baldy Switching Station and the Copco2 Substation.

DISCUSSION

With the facility improvements made over the last 10 years, all normal transmission sources are now capable of serving the entire Ashland regional load (57.53 MW in 2013) into the long term future. The present looped configuration and available backup transmission paths provide the City with additional service integrity.

Reliability criteria established for many major utilities dictates that any transmission line supplying 50 MW or more, or two or more substations, should be provided with the an adequate alternate looped source, if such capability can be provided at a reasonable cost. The Copco2 and Sage Road backup sources satisfy this reliability concern and transmission service to the region should be satisfactory for the foreseen future.

A permanent fault on the 5.4 mile 115 kV Line 82 between the Ashland 115 kV breaker (2R266) and the Oak Knoll 115 kV breaker (2R262) would interrupt supply to the entire City of Ashland for some period of time. Restoration of power would be the responsibility of PacifiCorp. If this does happen, PacifiCorp has stated that they will first remotely open the isolation switches at Oak Knoll and Ashland Substations and remotely close the 115 kV breakers to restore power to Ashland and Oak Knoll. Local PacifiCorp crews would then need to be dispatched to find the faulted segment and isolate it via manually operated line switches before restoring power to Mountain Avenue Substation. If possible, all customers would be restored before line crews would begin repair work on the faulted line segment.

To reduce the impact of a 115 kV fault to the City, it would be necessary for PacifiCorp to install additional 115 kV circuit breakers and protective relaying to help automatically restrict the outage to a smaller portion of their transmission system. Alternatively, more remotely operated isolation switches could be installed. However, the present level of sectionalizing provided by PacifiCorp is typical for the number of substations and total number of customers involved. Improvements to the 115 kV system sectionalizing capability could be a point of future discussions between the City and PacifiCorp.

The weak link in the transmission system is the 0.81 mile 115 kV radial segment tapped off Line 82 that serves Mountain Avenue Substation. An outage on this line would de-energize Mountain Avenue Substation until repairs are completed. This line is owned by BPA. As discussed above, an outage along Line 82 between Oak Knoll and Ashland Substations would require manual switching in order to restore service to Mountain Avenue. Although it would be desirable to have this tap looped and the switching automated, it is unlikely either will happen and this situation is not unusual given the short length of this tap.

PacifiCorp has provided a summary of transmission outages affecting service to the City of Ashland. Since 2003, there have been 19 outages of greater than 15 minutes with an average outage time of approximately 54 minutes and a most common outage time of 22.5 minutes. BPA also provided an incomplete outage report for Mountain Avenue Substation which listed four unique events in addition to some of the transmission outages provided by PacifiCorp. A complete list of the outages referenced here can be found in Appendix C.

B. SUBSTATION SYSTEMS

EXISTING SYSTEMS

Three substations provide distribution service to the City of Ashland. The City itself owns no primary transformation facilities. PacifiCorp owns both the Ashland and Oak Knoll Substations providing service to the City of Ashland distribution points-of-delivery (POD) and BPA owns the Mountain Avenue Substation providing service to the City of Ashland distribution point-of-delivery (POD). All PODs are 12.47 kV.

Since the previous study, the City has extended the distribution rack at Mountain Avenue Substation to add more feeder positions, upgraded the protective devices at Ashland and Mountain Avenue Substations, and installed a Supervisory Control and Data Acquisition (SCADA) system that now includes both Ashland and Mountain Avenue Substations. The City of Ashland SCADA system allows real time monitoring and control of connected system devices, such as substation reclosers and voltage regulators, from a computer terminal in the Electric Department main office. The addition of Oak Knoll Substation Feeders to the SCADA infrastructure is currently planned.

The City purchases power from BPA with power delivered through a General Transfer Agreement via the PacifiCorp transmission system and facilities as described below. Under its contract with the City, PacifiCorp is responsible for providing service consistent with prudent utility practices. BPA meters these independent points of delivery as identified in Table 5-2.

Table 5-2
BPA Metering Designation

Substation	Feeder Name	Meter Number
Ashland	Business/North Main/Rail Road/North Mountain	575
Oak Knoll	East Main	1705
	Highway 66	1014
	Highway 99	1304
Mountain Avenue	Morton/South Mountain/Wightman	1820

The existing substation transformer nameplate capacity, manufacture date, winter ratings, and the transformation capacity available to serve City loads are shown in Table 5-3.

Table 5-3
Transformer Capacity Available to the City

Substation	Transformer	Transformer Maximum Nameplate Rating (MW)[1,5]	Maximum Winter Planning Rating (MW)[2,3,5]	Deduct PacifiCorp Loads (MW)[4]	Total Capacity Available (MW)[5,6]
Ashland	T-3499 (1974)	11.6/15.5/19.4 @ 65° C	26.1 @ 65° C	5.43	13.97
Mountain Ave.	T-1573 (1978)	13/17.4/21.7 @ 65° C	30 @ 65° C	0	21.73
Oak Knoll	T-3234 (1967)	11.6/15.5/19.4 @ 65° C	23.3 @ 65° C	8.35	11.05
	T-3856 (1992)	14.6/19.4/24.3 @ 65° C	29.1 @ 65° C	0	24.25
Total Capacity Available (2 stages of fans @ 65° C rise)					71
Total with Oak Knoll T-3856 Out of Service (Others operating with 2 stages of fans @ 65° C rise)					46.75
Total with Ashland Out of Service (Others operating with 2 stages of fans @ 65° C rise)					57.03
Total with Mountain Avenue Out of Service (Others operating with 2 stages of fans @ 65° C rise)					49.27

Notes: 1. Based on nameplate rating and temperature rise. IEEE C57.91, standard 55° C rise rating was replaced by 55°/65° C in approximately 1966 and again by 65° C rise in 1977.
2. The winter planning rating for the PacifiCorp substation transformers was provided by PacifiCorp.
3. The winter planning rating for the BPA substation transformers is unchanged since the previous study at 138% of the normal maximum value.
4. PacifiCorp peak load is determined from each PacifiCorp transformer peak minus the city's peak for the same transformer.
5. MW values assume a 0.97 power factor.
6. Based on transformer maximum nameplate rating with 65° C rise.

For each of the four substation transformers normally serving the City of Ashland, Table 5-4 shows the summer and winter ratings as well as peak load and capacity used under recent peak conditions. It is clear that under normal operating conditions, the existing substation transformation capacity can adequately support the City's present summer and winter peak loading in addition to PacifiCorp load. However, based on power flow modeling results in Chapter 7, the transformers may not have adequate capacity to serve future loads under some contingency operating conditions.

Table 5-4

Ashland Region Load Data (Including PacifiCorp Loads)

	Winter			Summer		
Substation (Transformer)	**kVA Load$_1$**	**Transformer Capacity (kVA)**	**Capacity Used**	**kVA Load$_2$**	**Transformer Capacity (kVA)**	**Capacity Used**
Ashland (T-3499)	19,324	26,900	71.8%	14,279	20,000	71.4%
Oak Knoll (T-3234)	14,816	24,000	61.7%	9,876	20,000	49.4%
Oak Knoll (T-3856)	8,546	30,000	28.5%	8,608	25,000	34.4%
Mountain (T-1573)	14,841	31,000	47.9%	16,546	22,400	73.9%
TOTAL	57,527	111,900	51.4%	49,310	87,400	56.4%

Notes: 1. Based on winter peak data from December 2013 with 100 A of load transferred from Ashland to Mountain Avenue Substation due to winter 2013-2014 construction on A2002 circuit.

2. Based on summer peak data from July 2013.

One-line diagrams of each substation are presented in Appendix B as Figures B-3, B-4 and B-5. A brief description of each substation and its facilities that serve the City follows:

ASHLAND SUBSTATION

At Ashland Substation, the City takes delivery from the regulated 12.47/7.2 kV bus through one PacifiCorp secondary 1200 A breaker (5R241). This PacifiCorp breaker feeds a City-owned distribution rack and four City distribution reclosers serving four feeder circuits. Both the substation and the City-owned distribution rack were constructed in 1960s.

The City of Ashland owns four reclosers serving the City feeders from the Ashland Substation and the City's distribution rack includes a fused bypass arrangement for each feeder, should a recloser be out-of-service or require maintenance. The feeder reclosers are rated 560 A with 400 A bypass fuses.

In 2013 the City replaced and upgraded the recloser controllers, placing them in an existing City owned and refurbished building across Nevada Street from the Ashland Substation. The City has implemented SCADA capability for these four feeders and intends to replace the distribution rack in-place in 2014 due to age, reliability, and safety concerns.

Also in 2013, PacifiCorp upgraded the 69 kV terminal of the Ashland Substation to 115 kV and removed the 69/115 kV auto-transformer. The substation is now looped at 115 kV. Distribution facilities are served through a 116 kV x 12.47/7.2 kV, 12/16/20 MVA transformer (T-3499) with a manufacture date of 1974, three single-phase voltage regulators, and a 12.47 kV distribution rack with main and auxiliary buses. The 115 kV transmission source from Talent Substation and Voorhies Crossing is protected with a primary circuit switcher. The 115 kV source on Line 82 from Oak Knoll Substation has a disconnect switch which can be remotely operated.

In addition to breaker 5R241, a 15.5 kV, 1200 A secondary breaker (5R245) serves the PacifiCorp Valley View distribution circuit. Should breaker 5R241 serving the City fail or need to be removed from service, City loads would be protected by the City-owned reclosers, or 400A City owned recloser by-pass fuses, or transferred via the auxiliary bus to breaker PacifiCorp

5R245. Breaker 5R245 is scheduled to be replaced with a 1200 A rated breaker before the end of 2014. It will have the capacity to serve all Ashland Substation load in addition to the normal PacifiCorp loads should the need arise.

The Ashland Substation transformer (T-3499) is not loaded as heavily as it was in the previous study, but it remains above 71% of maximum rating under both summer and winter peak conditions (Table 5-4).

OAK KNOLL SUBSTATION

At Oak Knoll Substation, PacifiCorp provides 12.47 kV service to the City from three distribution breaker positions serving three separate PODs and City feeder circuits. City ownership of the Oak Knoll feeders begins just outside the substation.

The PacifiCorp Oak Knoll Substation, constructed in 1965, has two 115 kV incoming terminals serving two power transformers with both transformers normally in service. Transformer T-3234 (Bank #1) rated 116 kV x 12.47/7.2 kV, 12/16/20 MVA with a manufacture date of 1967, has load-tap changer regulation and normally feeds the substation bypass bus serving the PacifiCorp Siskiyou distribution feeder and the City of Ashland Highway 99 feeder. Transformer T-3856 (Bank #2) rated 116 kV x 12.47/7.2 kV, 15/20/25 MVA with a manufacture date of 1992, has secondary voltage regulation and normally feeds the substation main bus serving the City of Ashland Highway 66 and East Main feeders.

Feeder breakers 5R56 and 5R93 are rated for 600 A, and 5R70 is rated for 1200 A. The substation also has a normally open 1200 A tie breaker that can connect the main and bypass busses. The substation configuration offers flexible switching should any one device fail or need to be out-of-service for maintenance. The City of Ashland owns no equipment within the Oak Knoll Substation.

Under normal operating conditions, the transformer capacity at Oak Knoll is adequate for the expected peak loads. However, the loss of transformer T-3856 under peak conditions could create an overload condition on transformer T-3234 in the near future (Table 5-4). This was also noted in the previous study.

The City is in the process of installing three separate pole-mounted reclosers just outside the PacifiCorp Oak Knoll Substation. This improvement will give the City the ability to directly control these feeders without involving PacifiCorp staff. The installation will include equipment with SCADA capability so the City will have the capability to remotely monitor and control these feeders.

MOUNTAIN AVENUE SUBSTATION

At Mountain Avenue Substation the site, high voltage equipment, control building and ancillary components are owned by BPA. The City takes delivery of power at 12.47 kV and owns the three-phase voltage regulator, two distribution racks plus sectionalizing equipment, and the six distribution reclosers and feeder getaway facilities presently serving four feeder circuits. The City also owns panel-mounted feeder recloser controllers and SCADA system equipment placed inside the BPA control building.

The BPA Mountain Avenue Substation, constructed in 1994, has one 115 kV incoming source. Distribution facilities are served through a 115 kV x 12.47/7.2 kV, 12/16/20 MVA rated transformer (T-1573) with a 1976 manufacture date and secondary voltage regulation feeding a 12.47 kV distribution rack with main and auxiliary busses. A 115 kV circuit switcher provides transformer protection.

The original distribution facilities, consisting of a rack serving three City feeders through 560 A reclosers, were expanded by the City in 2010 to include the addition of a second distribution rack serving up to three additional City feeders. The distribution racks are configured with main and auxiliary busses allowing flexible switching arrangements so that load can be transferred to another source or circuit should a recloser need to be taken out-of-service. The racks are tied together via gang-operated load break tie switches and the second (new) distribution rack also contains a transformer bay to be served from a future second power transformer.

Additional information regarding substation equipment, ratings, loading, and capacity is presented and discussed elsewhere in this section.

PACIFICORP AND BPA SUBSTATION IMPROVEMENT PLANS

According to BPA, there are no planned substation improvements scheduled to take place in the intermediate future. PacifiCorp intends to replace the existing feeder relays at Oak Knoll Substation and build a new control house in the near future. PacifiCorp will also replace breaker 5R245 at Ashland Substation with a 1200 A breaker by the end of 2014.

DISCUSSION

GENERAL

In the previous study, discussions regarding equipment loading and system capacity focused on meeting winter peak demands. Since then, the summer peak demand has exceeded 40 MW and is often greater than or equal to the winter peak demand from the same year, as indicated in Figure 3-3. As stated in the Load Forecast chapter, it is expected that if a 1 in 10 year warm weather event were to occur in 2014, the resulting peak demand would be about the same as the 43.49 MW cold weather peak observed in December 2013. Figure 3-7 shows City's peak demand and growth with the transformation capacity available to the City. The summer demand must be monitored closely since electrical equipment such as transformers, regulators, and overhead lines have lower capacity in the summer compared to winter due to the higher ambient temperature.

Figure 3-7 in Chapter 3, the Power Flow results in Chapter 7, and Tables 5-3 and 5-4 help illustrate the ability of the City to serve current and future loads under varying conditions and contingency scenarios with existing transformer capacity. As noted in Chapter 7, the data demonstrates that sufficient capacity is available to serve the City for the next 10 year period under normal conditions. However, the loss of the Mountain Avenue or Ashland Substation transformers under current peak load conditions would severely overload the remaining transformers and expose the city to the possible inability to meet the peak demand load. This concern was noted in the previous report and remains important today.

The best short-term solution to deal with the inadequate transformation capacity and sectionalizing limitations is to have pre-determined sectionalizing practices to transfer load, with alternative plans for various outages and emergency conditions. Sectionalizing plans should be written procedures and these plans should include a listing of loads that can be taken out of service if necessary. Critical loads that must be restored quickly should also be identified in the sectionalizing plans. These are fairly low probability scenarios, but it is important to have developed appropriate plans to deal with these emergency situations. We also recommend that the City continues to strengthen ties between feeders served from different substations and plan to add a second transformer at the Mountain Avenue Substation.

PacifiCorp has indicated that if any transformer at Ashland or Oak Knoll Substation fails and a mobile transformer is required, it may be possible to place a unit from Medford in service within approximately 6 hours or less. If the unit stationed at Medford is in use, a duration of 14 hours is typically required.

BPA has indicated that in the event of the Mountain Avenue Substation transformer failure, the initial action would need to be taken by the City to transfer load to PacifiCorp's Ashland and/or Oak Knoll Substations. If a mobile transformer is required, BPA would first try to provide a unit located at Alvey Substation in Eugene, Oregon. Should the failure occur while the mobile transformer in Alvey was deployed elsewhere, a mobile transformer from the Ross Complex in Vancouver, Washington would be provided. BPA has stated that restoration and installation time would vary due to site conditions, distances, weather, and crew availability. The BPA substation maintenance division estimates it may take a long as 48 hours to ready, deliver, install, and energize a mobile transformer for Mountain Avenue once notice is received.

FUTURE SUBSTATION EXPANSION

The 2003 study included recommendations for substation expansion. Due to the recession that began in 2008, the growth seen between 2003 and 2008 was not sustained, and the suggested improvements could be delayed. However, despite the recession, significant growth in peak demand has occurred since 2003. The power flow analysis indicates that the loss of either the Ashland or Mountain Avenue Substation transformer under current peak load conditions would lead to an inability to serve customers without significant transformer overload and accelerated transformer aging.

The Ashland Substation is located close to the City's load center, but this facility is fairly congested with little room for expansion. The City is considering replacing the 12.47 kV distribution rack in-place in order to update but not expand this facility. The existing rack is old and its condition is deteriorating. The new distribution rack improvement would enhance flexibility and maintenance, however, the new distribution rack would still be served from a single PacifiCorp breaker. The City recently (2011) considered construction of a City-owned substation across Nevada Street from PacifiCorp's Ashland Substation, but this concept was not pursued. It is suggested that the option of a new substation near Ashland substation should still be evaluated before the Ashland Substation rack is replaced. The cost of a new rack would still be incurred with either approach. In addition, the City has access to the necessary land and the control building is already in place. These factors will reduce the payback period for a new substation.

The Oak Knoll Substation is located in the southeast region of the City's service area and is well situated for load growth in its general vicinity. Due to its location, this substation has rather limited ability for future expansion that could efficiently reach the City's present concentrated load center. As previously mentioned, the City is installing City-owned sectionalizing reclosers on the three Oak Knoll feeders outside the substation so that the City has control and can monitor these feeders.

The most practical substation facility for consideration of future expansion and improvement is the Mountain Avenue Substation. This substation, constructed in 1994, is centrally located to the City's load and consists of a large developed site suitable for expansion. In 2008 the City expanded facilities it owns by adding a second distribution rack with three new feeder bays and transformer bay. The Mountain Avenue Substation is constructed so that capacity can be increased with the addition of a second power transformer installed as load develops.

If loads grow as expected, the City will need additional substation transformation capacity within the intermediate (10 year) future to comply with the single-contingency planning criteria. This added capacity will be at the City's expense and will be necessary to allow the City to:

- Meet its expected peak loads.
- Provide single contingency outage flexibility at peak load.
- Reduce the exposure to lengthy outages while a mobile transformer is placed in service.

The recommended approach to meet these objectives is to add a second transformer at Mountain Avenue Substation. This places the additional capacity in a location that offers several advantages:

- Site is designed to accommodate a second transformer.
- Presently two additional feeder bays are unused and available for new feeders.
- Avoids the further feeder congestion at the Ashland and Oak Knoll substations.
- Strengthens the City's distribution feeders backup and sectionalizing capability.
- Strengthens the ability to carry peak load with one substation out of service.
- Mountain Avenue is an existing substation with sufficient room for expansion.
- Does not involve acquiring a new substation site.
- Does not require extensive planning or permitting.
- There is existing looped transmission to the site's radial tap.

SUBSTATION OWNERSHIP

Because the City takes delivery of all power at the 12.47/7.2 kV secondary voltage it must pay a Utility Delivery Charge (UDC) for all energy purchased through BPA substations and a General Transfer Agreement (GTA) charge for all energy purchased through PacifiCorp substations. The UDC charge was put in place in 1996 to recover the costs of owning, operating, and maintaining low-voltage facilities (at or below 34.5 kV). The GTA charge is designed to recover the cost of low voltage transfer service, such as service provided by PacifiCorp to Ashland's Oak Knoll and Ashland points of delivery.

Recently, both of these rates have changed. According to BPA, the last three transmission rate cases resulted in a UDC that did not fully recover costs. As of October 2013, the UDC increased by 25% for fiscal years 2014-2015 from $1.119 per kilowatt per month to $1.399 per kilowatt per month. BPA expects the current UDC rate to increase in every rate case until BPA achieves full cost recovery. Also in October 2013, the GTA rate went down to $0.82 per kilowatt per month. BPA does not have rate projections for the GTA rate, but expects this rate to stay roughly the same with adjustments for inflation over time.

A slight difference between the UDC and GTA is that UDC billing is based on the City's demand at the hour of BPA's transmission usage peak and GTA billing is now based on the customer system peak. So, while the GTA rate has been reduced significantly Ashland will now always be charged for this service based on the hour of the City's maximum peak demand instead of the City's demand on the hour of the transmission usage peak. This difference generally makes the billing determinant for the GTA slightly higher than the UDC, but in most cases it should not have a large effect on the City's bills.

The only way to reduce these delivery charges is to purchase power at the transmission voltage. This would occur with purchase and ownership of the Mountain Avenue Substation from BPA or construction of a new City-owned substation on Nevada Street across from PacifiCorp's Ashland Substation site.

In the recent past (2004-2011), the City performed an economic evaluation regarding the purchase of Mountain Avenue Substation from BPA. This evaluation took into account reduced power costs due to the elimination of the UDC and was based on an expectation that additional load would be moved to Mountain Avenue substation in future years. We suggest that this evaluation, which includes the substation estimated price and reasonable costs for normal operation and maintenance, be updated to reflect current and future UDC charges, substation load changes and new rates. The City should also take into account its ability to use tax-exempt financing rather than to pay PacifiCorp or BPA for facility improvements on a long-term basis.

While there are some cost savings to the City in not having complete ownership of the substations, there are also limitations and restrictions. This is especially true when planning for future improvements related to load growth or overall system reliability. Ownership would allow the City to independently determine substation facility needs and potentially reduce the total cost of providing service in the long run. However, the City would also assume the risk associated with owning substation and transmission facilities as well as operations and maintenance costs. With purchase of Mountain Avenue Substation, the City would need to come to an agreement with BPA for access to a mobile substation or transformer until the second transformer is added.

Based on the calendar year 2013 average system monthly peak of 13,385-kW with the UDC rate of $1.399/kW, purchase of the Mountain Avenue Substation could save the City a maximum of $224,714 annually. These savings would be reduced to some extent by the necessary increase in maintenance and operation costs. A second transformer at a City-owned Mountain Avenue Substation would allow the City to transfer load from other substations and further reduce delivery charges. With a GTA rate of $0.82/kW and an average monthly peak of 8,743 kW, construction of a City owned Nevada Street Substation could save the city $86,031 annually before accounting for operations and maintenance costs.

IMPLICATIONS OF NERC BULK ELECTRIC SYSTEM CLASSIFICATION (BES)

FERC has recently issued its Final Ruling regarding the NERC definition of the Bulk Electric System (BES). In its ruling it accepted the NERC definition of the BES. Portions of the electric power grid falling under the BES definition are required to maintain a specified level of reliability and security. This imposes additional record-keeping and documentation requirements on the owning utility and can result in the imposition of fines if the NERC requirements are not met. The basic rule is that transmission facilities operating at 100 kV or higher are considered part of the BES. However this voltage limit is not an absolute dividing line. There are several “Exclusions” and “Inclusions” that are applied that depend on system criteria other than voltage.

If the City is required to purchase the 115 kV radial transmission line along with Mountain Avenue Substation, it is our opinion that <u>none</u> of the City-owned 115 kV system would create a condition that would cause the City‘s 115 kV system to fall into the BES designation. This is because of Exclusion E-1 in the NERC BES definition as described in the FERC ruling:

“Exclusion E1 provides as follows:

Radial systems: A group of contiguous transmission Elements that emanates from a single point of connection of 100 kV or higher and:

a) Only serves Load. Or,
b) Only includes generation resources, not identified in Inclusions I2, I3, or I4, with an aggregate capacity less than or equal to 75 MVA (gross nameplate rating). Or,
c) Where the radial system serves Load and includes generation resources, not identified in Inclusion I2, I3, or I4, with an aggregate capacity of non-retail generation less than or equal to 75 MVA (gross nameplate rating).

Note 1 – A normally open switching device between radial systems, as depicted on prints or one-line diagrams for example, does not affect this exclusion.

Note 2 – The presence of a contiguous loop, operated at a voltage level of 50 kV or less, between configurations being considered as radial systems, does not affect this exclusion.”

Since the City’s system would serve only Load (as defined by NERC) and would be a radial system it would fall completely under Exclusion E-1 and would NOT be considered as part of the BES, in our opinion. In order to formalize this exemption, the City would need to visit the NERC website and complete the BES Notification and Exception Process.

C. CONCLUSION

Over the last 10 years, PacifiCorp has made major improvements to the transmission facilities serving the City of Ashland. The current looped configuration and available backup transmission paths provide the City with satisfactory service reliability and capacity into the long term future. The substation facilities serving the City of Ashland provide adequate capacity to serve the City's winter and summer peak load under normal conditions. However, with additional load growth and in contingency situations, the City's electric system may not fully meet the single contingency outage criteria. As the City considers options for additional transformation capacity, it should also re-visit the option of substation ownership to reduce operating costs.

D. RECOMMENDATIONS

Recommendations related to transmission and substation facilities serving the City of Ashland are outlined below in their order of priority. Summary descriptions and associated costs are shown in Table 2-1 and are provided below. Estimates are based on the assumption that the City pays directly for the improvements. These estimates do not include any site acquisition, establishment of right-of-ways and easements, or environmental and permitting. The proposed improvements are evaluated using an economic method called Simple Payback. Simple Payback is often used as a quick, but rough, approximation tool for appraising proposed investments. It does not factor in operation and maintenance costs or risk of ownership. It is suggested that the City thoroughly explore each recommended improvement and determine complete ownership costs prior to moving forward with any improvement option.

IMPROVEMENT 1 – EVALUATE OPTIONS FOR CITY OWNERSHIP OF MOUNTAIN AVENUE AND ASHLAND SUBSTATIONS.

<u>Mountain Avenue Substation</u>
In September 2011, BPA offered to sell the substation and its 0.81-mile 115 kV radial transmission line for $1,645,000. The City made a counter-offer of $1,290,000 on February 29, 2012. Assuming a purchase price of $1,290,000 and the present annual UDC charges of $224,714, the simple payback would be about 6 years. It is our opinion that a payback shorter than 10 years merits serious consideration. This payback could be even shorter if increases in the UDC occur as expected and peak loads continue to increase.

<u>Ashland Substation Replacement</u>
Prior to replacement of the Ashland Substation rack, consideration should be given to construction of a new City substation directly across Nevada Street on property that is already owned by the City. We are referring to this possible substation as “Nevada Street Substation”. Based on budgetary cost estimate of $1,200,000 and present delivery charges of $86,034, the simple payback would be 14 years ($1,200,000/86,031). Based on this payback duration, this improvement is not as attractive as purchase of Mountain Avenue substation. However, if allowances are made for expected increases in the GTA charges, the payback period could be shorter. Also, replacement of Ashland Substation with a City-owned substation would provide the City with much greater operational flexibility and growth options. Because of this, it is recommended that the substation ownership evaluation include replacement of Ashland substation as well as purchase of Mountain Avenue Substation.

IMPROVEMENT 2 – MOUNTAIN AVENUE SUBSTATION PURCHASE

If the updated evaluation described above in Improvement 1 shows the expected cost benefits and an acceptable price can be negotiated, it is recommended that the City proceed with purchase and ownership of the BPA Mountain Avenue Substation. This purchase would include all facilities owned by BPA including the 115 kV radial transmission line, circuit switcher, power transformer, subsurface and buswork facilities, control building, protection devices, ancillary equipment and site, excluding BPA's metering and telemetry devices to be retained by BPA. Engineering estimates of the value of this equipment has been performed in the recent past.

Based on terms offered by BPA in prior negotiations, this acquisition would have to include the purchase by the City of the 0.81-mile 115 kV transmission tap and termination facilities. The transmission line terminal consisting of three-way disconnects with remote supervisory control would be retained by PacifiCorp with only the tap disconnect owned and made operable by the City. With this purchase, the City would need to form an agreement with BPA for access to a backup mobile transformer or substation until the second transformer is added. In the long term, the relays for the existing transformer should be upgraded to include differential protection elements.

IMPROVEMENT 2A – EXPAND MOUNTAIN AVENUE SUBSTATION

Expand the Mountain Avenue Substation with installation of a second power transformer, circuit switcher, voltage regulator, structures, foundations and ancillary facilities as necessary. Installation of this transformer in a City-owned substation would allow transfer of load from other substations and further reduction of monthly delivery charges. This improvement includes installation of the necessary subsurface facilities and placement of the necessary control devices and ancillary equipment within the existing control building. In 2008 the City installed the second distribution rack including transformer bay and feeder bays needed to interconnect with this second transformer.

Cost Estimate:	Total Cost	$1,008,000

IMPROVEMENT 3 – UPGRADE OR REPLACE EXISTING ASHLAND SUBSTATION DISTRIBUTION RACK.

Due to age, reliability, and safety concerns, the existing 12.47 kV distribution rack inside Ashland Substation should be replaced in the near future. The best alternative to achieve this depends on the outcome of the substation ownership evaluation described in Improvement 1 as well as the City's long-term plans for the City-owned electric system. The lower cost option would be to simply replace the existing 12.47 kV distribution equipment with new equipment inside Ashland Substation. The other option would be to construct a new substation nearby. Since the City has already converted an existing structure into a control house and purchased new recloser controls, this work can be incorporated into either option.

Cost Estimate:	Substation (City-owned facility)	$1,200,000
	Distribution rack (City construction)	250,000
	Total Cost	$1,450,000

CHAPTER 6

DISTRIBUTION SYSTEM EVALUATION

CHAPTER 6

DISTRIBUTION SYSTEM EVALUATION

A. BACKGROUND

The City of Ashland electrical distribution system was evaluated using recent peak demand in addition to light load conditions as the base case loads for the system analysis. To produce 5- and 10-year estimates for analysis and planning, the base-case system peak demand has been adjusted to increase in correlation with population growth as outlined in Chapter 3. Specific areas of growth and allocations to the system model are covered in detail in Chapter 7. The loading conditions examined in this study are listed below in Table 6-1.

Table 6-1
Study Loading Conditions

	Base Case (Light)	Base Case (Peak)	5-Year (2018)	10-Year (2023)
Modeled Load	10.6 MW	43.45 MW	45.8 MW	48.3 MW

The preparation of this study is based on detailed distribution system information gathered from the City of Ashland GIS maps. The GIS maps include data on location, name, connectivity, size, and rating for system components such as conductors, transformers, capacitor banks, switches, protective devices, poles, and vaults. The model used in the analysis, which indicates analysis node and segment electrical data, is included in Appendix D.

B. DISTRIBUTION SYSTEM CAPACITY

According to recent modeling and analysis, the City's existing distribution system currently provides reliable service and acceptable voltage levels for all loading conditions up to the historical peak load when operating in a normal system configuration. Tables 6-2A and 6-2B present the energy use and peak demand data at all Mountain Avenue and Oak Knoll feeders for the 2013 service year. Substation totals and system totals are summarized in Table 6-2C. The data in Tables 6-2A, 6-2B, and 6-2C shows that the City maintains a relatively high load factor, which benefits both the utility and the customer. These tables are located at the end of this chapter.

Data for Mountain Avenue substation feeders came from the City of Ashland SCADA system. Oak Knoll substation feeder data and Ashland substation totals data came from BPA individual points of delivery. Individual feeder load data is not available for Ashland substation prior to December 2013 when it was incorporated into the City's SCADA system. As soon as Oak Knoll Substation is incorporated into the City's SCADA system, the City will have local access to load data for all system feeders on an individual feeder basis. Additionally, archived demand and energy use data for each point of delivery is available on the BPA website going back to 1994.

Another useful aid to help visualize system load characteristics are the winter and summer daily load profiles as seen in Figure 6-1 and 6-2, respectively. Peak loads are represented for each hour of the day, averaged separately for weekdays and weekends. The winter load profile, Figure 6-1, shows a trend similar to what was seen in the 2003 study with peaks in the morning and early evening hours as expected for a predominantly residential load system. The summer load profile, Figure 6-2, shows a different single peak characteristic that can most likely be attributed to air conditioning load. The general patterns seen in these daily load profiles can give the City a better idea of how to achieve system load balancing if needed, i.e. at which times of the day load might want to be shifted or additional loads encouraged, such as the operation of various motors to fill reservoirs or operate lift stations.

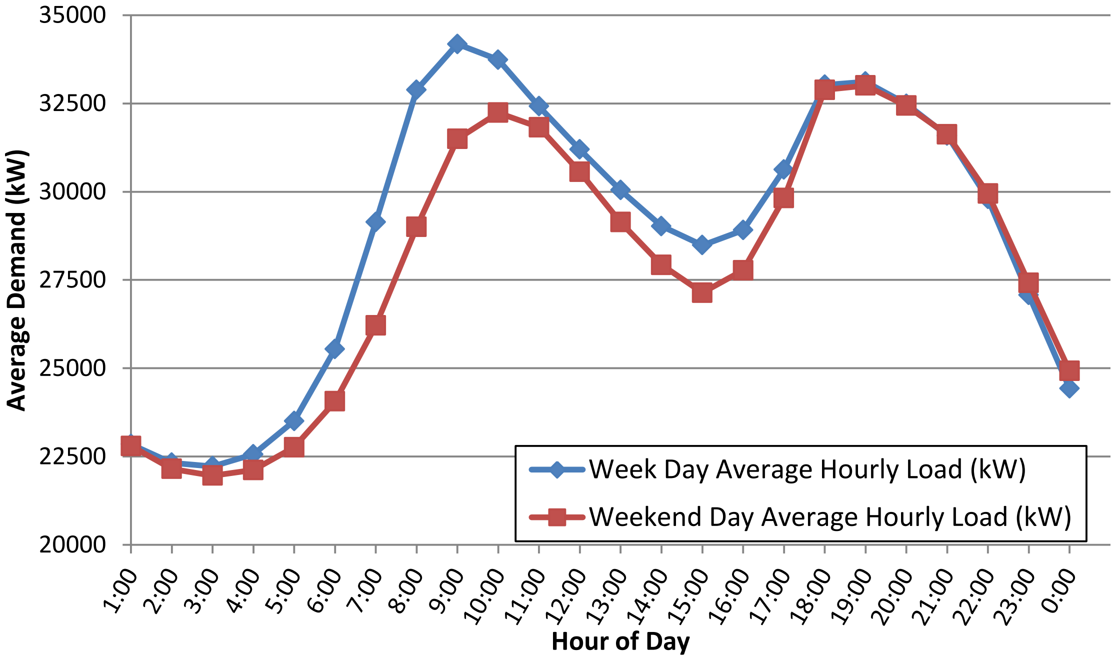

Figure 6-1: Average hourly peak load for December, 2013.

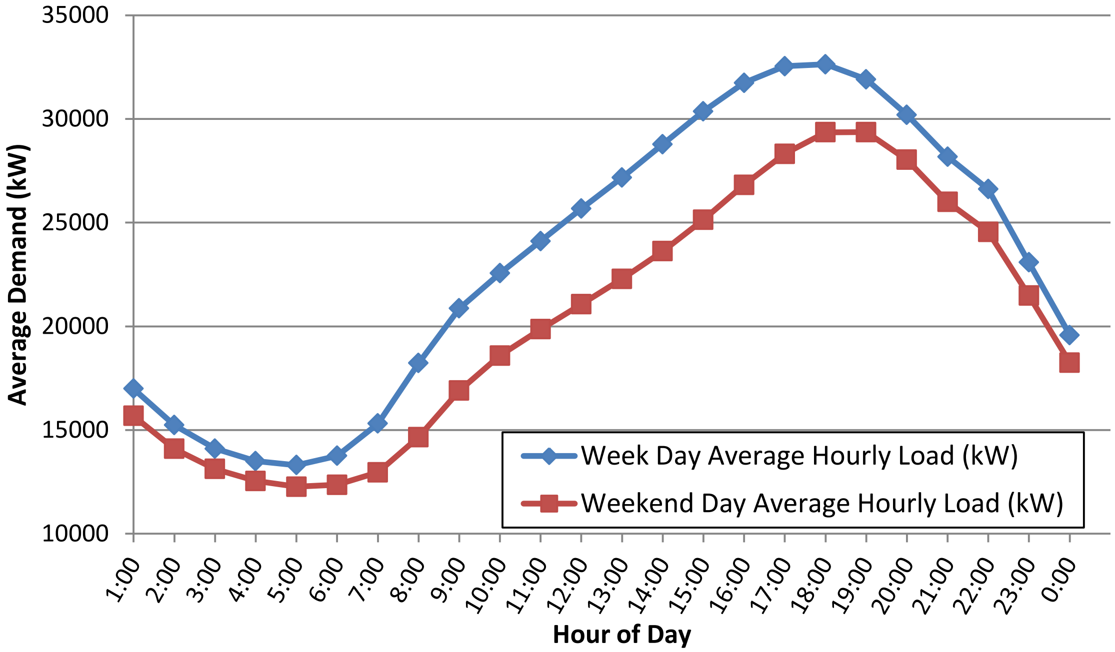

Figure 6-2: Average hourly peak load for July, 2013.

The City of Ashland provides quality electric service and has made many significant system improvements since the last study. With any one feeder out-of-service, the City now has the ability to serve loads from adjacent circuits even under peak conditions. However, loss of some feeder circuits during summer peak conditions will load parts of the system to capacity. Additionally, loss of a substation transformer at peak load can lead to severe transformer overload conditions at other substations. These conditions will become more severe as load growth occurs and could lead to the City not being able to meet single contingency outage criteria in the future without an increase in system capacity.

On the basis of the most recent system peak (December 2013), all conductors and substation transformers have sufficient capacity to serve this peak load under normal operating conditions. However, loads will need to be rebalanced between feeders and additional transformation capacity will need to be added before the end of this planning period in order for the City to provide reliable service with substation or feeder outage conditions at the projected peak load of 48.3 MW. The electrical distribution system growth expansion patterns and necessary feeder additions, as they relate to system loading, are explained in the Power Flow Analysis Chapter.

DISTRIBUTION SYSTEM

The City's electric system serves customers from 10 distribution feeders, with a total of 12 substation feeder positions available. Tables 6-3A and 6-3B summarize the existing feeder voltage ratings; backbone conductor characteristics, capacities, kW ratings, recommended loading, and actual loading during the December 2013 peak.

Table 6-3A
Existing Feeder Loading – Normal Conditions (SUMMER)

		Feeder Main Conductors			Peak Load		Peak Load % of Conductor	
Substation Feeder	Voltage (kV)	Size/Material	Rating		Present (kW)	Rec'm'd (kW)	Rating	Rec'm'd Loading
			Amps	KW				
ASHLAND								
A2000 - Business	12.47/7.2	556 AAC	600	12,570	5,591	7,500	44.48%	74.55%
A2001 - North Main	12.47/7.2	750 kcmil AL & 556 AAC	490	10,266	5,924	7,500	57.71%	78.99%
			600	12,570			47.13%	
A2002 - Railroad	12.47/7.2	750 kcmil AL & 556 AAC	490	10,266	2,026	7,500	19.74%	27.01%
			600	12,570			16.12%	
OAK KNOLL								
5R56 - Highway 99	12.47/7.2	336 AAC	435	9,114	6,470	7,500	70.99%	86.27%
5R70 - Highway 66	12.47/7.2	336 AAC	435	9,114	4,660	7,500	51.13%	62.13%
5R93 - East Main	12.47/7.2	336 AAC	435	9,114	3,970	7,500	43.56%	52.93%
MOUNTAIN AVENUE								
M3006 - N. Mountain	12.47/7.2	750 Al UG 556 AAC	490	10,266	1,001	7,500	9.75%	13.35%
			600	12,570			7.96%	
M3009 - Morton	12.47/7.2	750 Al UG 336 AAC	490	10,266	6,104	7,500	59.46%	81.39%
			435	9,114			66.98%	
M3012 - S. Mountain	12.47/7.2	556 AAC 336 AAC	600	12,570	4,791	7,500	38.11%	63.88%
			435	9,114			52.57%	
M3015 - Wightman	12.47/7.2	556 AAC 336 AAC	600	12,570	2,954	7,500	23.50%	39.39%
			435	9,114			32.41%	

Notes:
1. Peak load data is coincidental, from recent historical peak occurring December 2013.
2. All kW ratings assume a three-phase system with 97% power factor.
3. Conductor size/material data obtained from City staff and GIS maps.
4. Overhead conductors shown with summer ampacity ratings.
5. Recommended loading is for normal conditions, non-sectionalized.

Table 6-3B
Existing Feeder Loading- Normal Conditions (WINTER)

		Feeder Main Conductors			Peak Load		Peak Load % of Conductor	
Substation	Voltage	Size/Material	Rating		Present	Rec'm'd		Rec'm'd
Feeder	(kV)		Amps	KW	(kW)	(kW)	Rating	Loading
ASHLAND								
A2000 - Business	12.47/7.2	556 AAC	870	18,227	5,591	7,500	30.67%	74.55%
A2001 - North Main	12.47/7.2	750 AL UG	490	10,266	5,924	7,500	57.71%	78.99%
		556 AAC	870	18,227			32.50%	
A2002 - Railroad	12.47/7.2	750 AL UG	490	10,266	2,026	7,500	19.74%	27.01%
		556 AAC	870	18,227			11.12%	
OAK KNOLL								
5R56 - Highway 99	12.47/7.2	336 AAC	630	13,199	6,470	7,500	49.02%	86.27%
5R70 - Highway 66	12.47/7.2	336 AAC	630	13,199	4,660	7,500	35.31%	62.13%
5R93 - East Main	12.47/7.2	336 AAC	630	13,199	3,970	7,500	30.08%	52.93%
MOUNTAIN AVENUE								
M3006 - N. Mountain	12.47/7.2	750 Al UG	490	10,266	1,001	7,500	9.75%	13.35%
		556 AAC	870	18,227			5.49%	
M3009 - Morton	12.47/7.2	750 Al UG	490	10,266	6,104	7,500	59.46%	81.39%
		336 AAC	630	13,199			46.25%	
M3012 - S. Mountain	12.47/7.2	556 AAC	870	18,227	4,791	7,500	26.29%	63.88%
		336 AAC	630	13,199			36.30%	
M3015 - Wightman	12.47/7.2	556 AAC	870	18,227	2,954	7,500	16.21%	39.39%
		336 AAC	630	13,199			22.38%	

Notes: 1. Peak load data is coincidental, from recent historical peak occurring December 2013.

2. All kW ratings assume a three-phase system with 97% power factor.

3. Conductor size/material data obtained from City staff and GIS maps.

4. Overhead conductors shown with winter ampacity ratings.

5. Recommended loading is for normal conditions, non-sectionalized.

The power flow study indicates that during the study period, the loading of the main system feeder backbone circuits as presently configured would approach the loading levels shown in Table 6-4.

Table 6-4
Feeder Backbone Conductor Loading Under Growth Conditions

Feeder	2013 Peak	2018 Forecast (5.4% Growth)	2023 Forecast (11.2% Growth)
A2000 - Business	44.48%	45.27%	46.07%
A2001 - N. Main	57.71%	61.60%	64.52%
A2002 - Railroad	19.74%	20.71%	21.68%
5R56 - Hwy 99	70.99%	72.09%	77.57%
5R70 - Hwy 66	51.13%	52.23%	53.32%
5R93 - E. Main	43.56%	54.53%	65.50%
M3006 - N. Mountain	9.75%	12.19%	13.16%
M3009 - Morton	66.97%	68.07%	69.17%
M3012 - S. Mountain	52.57%	53.66%	54.76%
M3015 - Wightman	32.41%	33.51%	34.61%

Notes: 1. Peak load data is coincidental, from recent historical peak occurring December 2013.
2. Smallest backbone conductor used with summer ampacity ratings from table 6-3A.

All the feeders currently have adequate capacity to serve peak loads under normal conditions and under the emergency sectionalized conditions evaluated. However, some feeders are more heavily loaded than others. This loading imbalance reduces operational flexibility during emergency operating conditions. As future load growth occurs, the City will need to add additional feeders and strategically balance load between existing feeders to minimize feeder and conductor overloading under sectionalized conditions.

CAPACITOR BANKS

The City's electrical distribution system presently has eight 12.47 kV capacitor banks installed at various locations on distribution feeders. Capacitors are generally used to maintain adequate voltage and power factor, as well as reduce line losses. The existing capacitor banks, their feeder and locations, sizes, and types of control are described in Table 6-5.

Since the previous study, many of the existing capacitor banks have been relocated and controls have been added for automatic switching based on measured system conditions. These changes were implemented using recommendations in the previous study. Based on the analysis results of the present system configuration, no additional capacitor installations are recommended within this intermediate planning period. For general recommendations regarding capacitor placement and configuration, see Chapter 4.

Table 6-5
Ashland Electric System Capacitor Banks

Feeder	Location	Rating	Type and Status
A2000 - Business	Helman & Tracks	600 kVAR	Fixed "ON" At 12.47 kV
A2001 - N. Main	Maple Street	600 kVAR	Fixed "ON" At 12.47 kV
M3009 - Morton	Morton & East Main	600 kVAR	Fixed "ON" At 12.47 kV
M3012 - S. Mountain	S. Mountain & Iowa	900 kVAR	Automatic
M3015 - Wightman	N. Mountain & Clear Creek	600 kVAR	Automatic
5R56 - Hwy 99	35 Crowson Rd	600 kVAR	Automatic
5R70 - Hwy 66	Hwy 66 & Crowson Rd	600 kVAR	Automatic
5R93 - E. Main	3018 Green Springs Hwy 66	900 kVAR	Automatic

C. SYSTEM PERFORMANCE

SERVICE RELIABILITY

As discussed in Chapter 5, reliability of electric service is a primary consideration in system planning. The City's electric system should use a single contingency reliability criterion, which means that the outage of any single major component of the electric system cannot result in a prolonged outage to any customer.

The IEEE has developed specific guidelines through Standard 1366, Guide for Power Distribution Reliability Indices, to evaluate distribution reliability consisting of measures for monitoring outage duration and frequency. These reliability indices have received industry-wide acceptance and are divided into two categories, customer based and load based.

Customer based indices record the frequency and duration of outages from individual customers and are used mainly in residential areas. Load-based indices record the frequency and duration of outages and are relevant for circuits that serve industrial and commercial loads. The IEEE sustained interruption indices are listed below for convenience.

SAIFI -- System average interruption frequency index

$$\text{SAIFI} = \frac{\text{Total number of customers interrupted}}{\text{Total number of customers}}$$

SAIDI -- System average interruption duration index

$$\text{SAIDI} = \frac{\text{Sum of customer interruption duration}}{\text{Total number of customers}}$$

CAIDI -- Customer average interruption duration index

$$\text{CAIDI} = \frac{\text{Sum of customer interruption duration}}{\text{Total number of customer interruptions}}$$

ASAI -- Average service availability index

$$\text{ASAI} = \frac{\text{Customer hours service availability}}{\text{Customer hours service demand}}$$

SAIFI is expressed with a unit of outages per year for the average customer. Both the SAIDI and CAIDI are expressed in minutes, and ASAI is a percentage.

We suggest that the City establish a practice of determining the indices listed above annually or every few years and conform to these adopted standard utility practices. We acknowledge that steps are already being taken in this direction.

Table 6-6 summarizes the outage data provided by the City. While the data provided for this report is not comprehensive enough to determine the indices listed above, it is still informative and useful.

Table 6-6
City of Ashland Outage Data

Year	2012	2013
Number of Outages	113	86
Type		
Overhead	40%	60%
Underground	50%	40%
Cause		
Animals, Storms, & Cars	34%	31%
Equipment failure	24%	26%
Customer related	33%	43%
Duration		
Over 2 hours	22%	83%
2 hours or less	67%	13%

SYSTEM VOLTAGE LEVELS

In accordance with standards established by the American National Standard Institute (ANSI C84.1, Range A), the voltage ranges in Table 6-7, shown as acceptable voltage or allowable voltage drop, should be maintained throughout the City’s electric system.

The voltages shown are presented on a 120 volt base, however the percentages indicated apply to any voltage base, for example 12.47/7.2 kV, 480/277 V, etc., that is applicable to the location.

Table 6-7
Acceptable City of Ashland Voltage Levels

Facility	Acceptable Voltage or Allowable Voltage Drop (Volts)	Acceptable Percentage
Bus voltage range at substation.	122 - 126	102% - 105%
Maximum voltage drop along a distribution feeder.	8	
Voltage range at primary terminals of distribution transformers.	118 - 126	98% - 105%
Maximum voltage drop across distribution transformer and service conductors.	4	
Voltage range at customer meter.	114 - 126	95% - 105%
Voltage range at customers utilization equip.	110 - 126	92% - 105%

The Base Case Power Flow results indicate that present system voltages under peak conditions are at acceptable levels, with the maximum voltage drop on any feeder between substation and last customer at approximately 2.2%. However, all substation voltages should be monitored to ensure proper distribution voltage levels are maintained. In addition, during substation outages or feeder transfers, feeder voltage levels should be monitored to assure proper voltage levels are maintained.

The City should keep in mind the fact that minor voltage regulation can have noticeable effects on customer equipment. For example, a situation where typical household equipment experiences an under-voltage of 10 percent can result in reduced lighting output of 30 percent and can cut heating and range output by up to 20 percent. Over-voltage of 10 percent in household equipment can result in a reduction of lamp life up to 70 percent and cause overheating of heaters and ranges.

Today, customers expect an extremely high quality of service and reliable power supply. Momentary interruptions, voltage disturbances, and sine wave distortions that would have gone unnoticed a few years ago are not as well tolerated with modern day loads. Among these sensitive loads are business and home computers, cash registers, burglar alarms, digital clocks, home business center and entertainment equipment, and other sensitive equipment.

PHASE CURRENT IMBALANCE

The primary concern of imbalanced loading between phases of a circuit is the resulting unbalanced phase voltages. Unbalanced voltages can cause additional negative sequence currents to circulate in three-phase motors. This negative sequence current can lead to motors overheating. Load imbalance also causes excessive neutral currents, which can cause increased system losses and can affect ground relaying.

Because system loads are continually changing and since single phase loads are present on each feeder it is nearly impossible to achieve perfect phase balance. During high load conditions we recommend a policy of monitoring phase imbalance on each feeder. If the imbalance on any feeder exceeds 15%, loads should be shifted between phases to reduce imbalance to 10% or below. System balance may fluctuate seasonally or with system peaks but these fluctuations should not be excessive if the policy above is followed.

Imbalance percentages for Ashland and Mountain Avenue Substations are given on a per-feeder basis based on system load data from the City of Ashland SCADA system on December 11, 2013 at 9:00 AM. The actual winter peak occurred on December 9, 2013 but individual phase data from Ashland Substation were not available for this date. Railroad Feeder A2002 is not shown since it has been mostly out-of-service for re-conductoring since December 2013 when data capture began on Ashland Substation. Data for Oak Knoll Substation feeders was collected with line loggers in early March 2014 by City staff. Results are shown in Table 6-8.

The results show that under recent winter peak conditions, some feeders do not stay within the 15% criterion. We recommend that the City continue to monitor the imbalance on all feeders during peak load conditions, with special attention given to those with imbalance above 15% in Table 6-8. If the imbalance on these feeders continues to exceed 15%, action should be taken to shift load and reduce imbalance to below 10%. A period of monitoring is necessary following field changes to any feeder to identify the effect of the change on feeder balance. Additionally, phase balance should be considered prior to adding or reconfiguring any feeder loads.

Table 6-8
December 2013 Phase Imbalance

Substation	Feeder	Phase A (kW)	Phase B (kW)	Phase C (kW)	Imbalance (kW)	Imbalance (%)
Ashland	**A2000**	1786.0	1828.0	1316.0	327.3	19.9%
	A2001	1238.0	1536.0	2062.0	450.0	27.9%
Mountain Avenue	**M3006**	359.0	369.0	367.0	6.0	1.6%
	M3009	2462.0	2143.0	2613.0	263.0	10.9%
	M3012	1649.0	1632.0	1385.0	170.3	11.0%
	M3015	992.0	920.0	710.0	164.0	18.8%
Oak Knoll	**5R56**	941.8	1002.2	1432.1	306.7	27.3%
	5R70	985.0	1003.7	871.2	82.1	8.6%
	5R93	612.7	979.2	823.7	192.5	23.9%

Table 6-2A
2013 Mountain Avenue Substation Feeder Loading Summary

	Feeder M3006 - North Mountain						**Feeder M3009 - Morton**					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor
Jan	510,245	42,669	1,016	1/14/13 9:00	0.997	0.68	3,557,394	208,391	7,524	1/14/13 9:00	0.998	0.64
Feb	413,675	26,681	944	2/11/13 8:00	0.998	0.65	2,904,945	144,084	6,224	2/19/13 10:00	0.999	0.69
Mar	377,495	13,030	828	3/22/13 8:00	0.999	0.61	2,700,491	124,210	5,244	3/22/13 7:00	0.999	0.69
Apr	328,313	3,043	770	4/17/13 8:00	1.000	0.59	2,287,708	85,739	5,171	4/8/13 8:00	0.999	0.61
May	318,285	4,144	802	5/11/13 18:00	1.000	0.53	2,242,488	154,921	4,723	5/11/13 18:00	0.998	0.64
Jun	403,437	21,716	5,541	6/12/13 18:00	0.999	0.10	2,002,169	265,179	6,375	6/30/13 17:00	0.991	0.44
Jul	476,333	84,398	1,373	7/2/13 17:00	0.985	0.47	3,246,095	675,913	7,980	7/3/13 16:00	0.979	0.55
Aug	405,953	53,366	1,099	8/19/13 18:00	0.991	0.50	2,933,022	546,601	7,020	8/19/13 17:00	0.983	0.56
Sep	348,198	23,022	1,072	9/10/13 18:00	0.998	0.45	2,628,978	357,509	7,101	9/11/13 17:00	0.991	0.51
Oct	350,810	9,222	782	10/18/13 8:00	1.000	0.60	2,544,138	119,964	5,051	10/29/13 10:00	0.999	0.68
Nov	258,878	4,878	782	11/4/13 10:00	1.000	0.46	2,243,100	111,210	5,181	11/4/13 9:00	0.999	0.60
Dec	568,186	43,426	7,316	12/17/13 15:00	0.997	0.10	3,836,089	236,738	7,970	12/9/13 9:00	0.998	0.65
	Feeder M3012 - South Mountain						**Feeder M3015 - Wightman**					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor
Jan	2,370,187	-256,760	4,974	1/14/13 9:00	0.994	0.64	1,312,802	-168,719	2,683	1/14/13 8:00	0.992	0.66
Feb	1,971,879	-226,004	4,128	2/11/13 10:00	0.993	0.71	1,157,632	-146,099	2,371	2/12/13 8:00	0.992	0.73
Mar	1,762,579	-147,081	3,739	3/4/13 8:00	0.997	0.63	1,078,248	-179,365	2,226	3/4/13 8:00	0.986	0.65
Apr	1,536,427	-60,369	3,559	4/8/13 10:00	0.999	0.60	966,425	-177,631	1,964	4/8/13 8:00	0.984	0.68
May	1,402,702	-8,683	3,050	5/22/13 8:00	1.000	0.62	969,544	-147,174	2,239	5/10/13 16:00	0.989	0.58
Jun	1,144,236	33,264	3,228	6/30/13 18:00	1.000	0.49	841,466	-81,871	2,704	6/6/13 16:00	0.995	0.43
Jul	1,595,050	-112,434	3,836	7/2/13 15:00	0.998	0.56	1,214,846	16,675	3,050	7/25/13 16:00	1.000	0.54
Aug	1,393,796	11,177	3,126	8/6/13 16:00	1.000	0.60	1,061,708	-50,759	2,565	8/6/13 15:00	0.999	0.56
Sep	1,336,298	63,084	3,012	9/11/13 17:00	0.999	0.62	935,852	-132,173	2,599	9/11/13 16:00	0.990	0.50
Oct	1,591,429	-75,406	3,281	10/29/13 8:00	0.999	0.65	1,046,389	-203,470	2,050	10/29/13 8:00	0.982	0.69
Nov	1,283,889	-225,662	3,428	11/5/13 10:00	0.985	0.52	820,059	-154,016	2,079	11/4/13 18:00	0.983	0.55
Dec	2,430,995	-286,215	5,013	12/9/13 11:00	0.993	0.65	1,371,257	-177,171	2,978	12/9/13 9:00	0.992	0.62

Note: *Demand (kW) represents the peak coincident demand.

Table 6-2B
2013 Oak Knoll Substation Feeder Loading Summary

	Feeder 5R56 - Hwy 99						**Feeder 5R70 - Hwy 66**					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor
Jan	2,733,740	34,610	6,130	1/14/13 8:00	1.000	0.60	2,159,770	601,930	4,380	1/14/13 10:00	0.963	0.66
Feb	2,228,220	10,710	4,860	2/11/13 8:00	1.000	0.68	1,824,130	537,330	3,680	2/11/13 8:00	0.959	0.74
Mar	1,967,164	1,950	4,550	3/4/13 8:00	1.000	0.58	1,760,820	556,580	3,460	3/4/13 9:00	0.953	0.68
Apr	1,641,850	180	3,960	4/8/13 8:00	1.000	0.58	1,568,570	121,170	3,120	4/8/13 9:00	0.997	0.70
May	1,500,860	1,860	3,350	5/22/13 8:00	1.000	0.60	1,556,470	91,410	3,110	5/11/13 18:00	0.998	0.67
Jun	1,510,340	37,650	4,640	6/30/13 19:00	1.000	0.45	1,645,610	178,220	3,910	6/28/13 18:00	0.994	0.58
Jul	2,002,620	178,170	5,260	7/2/13 19:00	0.996	0.51	2,030,320	352,600	4,420	7/3/13 16:00	0.985	0.62
Aug	1,689,740	72,440	4,140	8/19/13 19:00	0.999	0.55	1,865,340	271,060	3,940	8/19/13 16:00	0.990	0.64
Sep	1,511,050	26,570	4,120	9/11/13 18:00	1.000	0.51	1,651,700	161,250	3,940	9/10/13 17:00	0.995	0.58
Oct	1,737,190	120	3,720	10/29/13 8:00	1.000	0.63	1,687,700	82,300	3,070	10/14/13 9:00	0.999	0.74
Nov	2,049,400	2,430	4,690	11/22/13 8:00	1.000	0.61	1,816,660	84,990	3,860	11/22/13 9:00	0.999	0.65
Dec	2,961,920	50,340	6,470	12/9/13 9:00	1.000	0.62	2,350,500	127,650	4,660	12/9/13 9:00	0.999	0.68

	Feeder 5R93 - East Main						-					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor						
Jan	1,864,940	2,300	4,040	1/14/13 9:00	1.000	0.62						
Feb	1,526,200	9,960	3,270	2/11/13 9:00	1.000	0.69						
Mar	1,442,020	59,960	3,050	3/4/13 8:00	0.999	0.64						
Apr	1,306,390	64,920	2,910	4/8/13 9:00	0.999	0.62						
May	1,257,880	85,190	2,480	5/10/13 17:00	0.998	0.68						
Jun	1,264,650	79,410	3,400	6/30/13 18:00	0.998	0.52						
Jul	1,621,500	74,440	4,050	7/2/13 17:00	0.999	0.54						
Aug	1,398,530	47,830	3,350	8/19/13 18:00	0.999	0.56						
Sep	1,252,170	34,740	3,420	9/11/13 18:00	1.000	0.51						
Oct	1,305,000	20	2,500	10/29/13 9:00	1.000	0.70						
Nov	1,471,340	710	3,270	11/22/13 9:00	1.000	0.62						
Dec	1,961,440	12,360	3,970	12/9/13 9:00	1.000	0.66						

Note: *Demand (kW) represents the peak coincident demand.

Table 6-2C
2013 Substation and System Loading Summary

	Ashland Substation						**Mountain Avenue Substation**					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor
Jan	5,020,420	23,710	10,260	1/14/13 8:00	1.000	0.66	7,858,000	119,150	16,100	1/14/13 9:00	1.000	0.66
Feb	4,109,250	4,480	8,220	2/11/13 8:00	1.000	0.74	6,542,000	72,300	13,400	2/11/13 9:00	1.000	0.73
Mar	3,825,060	240	7,920	3/4/13 8:00	1.000	0.65	6,012,025	98,125	11,925	3/4/13 8:00	1.000	0.68
Apr	3,362,290	1,960	7,040	4/8/13 8:00	1.000	0.66	5,207,225	126,300	11,475	4/8/13 9:00	1.000	0.63
May	3,338,240	34,030	6,900	5/11/13 18:00	1.000	0.65	5,074,100	252,325	9,900	5/10/13 16:00	0.999	0.69
Jun	3,311,090	172,520	9,440	6/30/13 18:00	0.999	0.49	5,223,825	518,625	13,200	6/13/13 12:00	0.995	0.55
Jul	4,427,340	563,420	10,650	7/3/13 17:00	0.992	0.56	6,613,150	898,900	16,050	7/3/13 17:00	0.991	0.55
Aug	3,791,840	356,620	8,750	8/6/13 17:00	0.996	0.58	5,933,275	795,300	13,475	8/19/13 16:00	0.991	0.59
Sep	3,341,720	125,260	8,150	9/12/13 18:00	0.999	0.57	5,336,900	519,400	13,800	9/11/13 17:00	0.995	0.54
Oct	3,631,070	890	6,830	10/29/13 9:00	1.000	0.71	5,674,950	115,925	11,100	10/29/13 9:00	1.000	0.69
Nov	4,155,070	15,680	9,020	11/22/13 8:00	1.000	0.64	6,348,525	66,575	13,200	11/22/13 9:00	1.000	0.67
Dec	5,633,420	79,760	11,740	12/9/13 9:00	1.000	0.64	8,339,500	124,025	17,000	12/9/13 10:00	1.000	0.66

	Oak Knoll Substation						**System Total**					
Month	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor	Energy (kWh)	Reactive (kVARh)	Demand* (kW)	Peak Date	Power Factor	Load Factor
Jan	6,758,450	638,840	14,400	1/14/13 9:00	0.996	0.63	19,636,870	781,700	40,650	1/14/13 9:00	0.999	0.65
Feb	5,578,550	558,000	11,730	2/11/13 8:00	0.995	0.71	16,229,800	634,780	33,270	2/11/13 9:00	0.999	0.73
Mar	5,170,004	618,490	10,870	3/4/13 8:00	0.993	0.64	15,004,445	716,855	30,715	3/4/13 8:00	0.999	0.66
Apr	4,516,810	186,270	9,970	4/8/13 9:00	0.999	0.63	13,086,325	314,530	28,245	4/8/13 9:00	1.000	0.64
May	4,315,210	178,460	8,600	5/11/13 18:00	0.999	0.67	12,727,550	464,815	25,075	5/11/13 18:00	0.999	0.68
Jun	4,420,600	295,280	11,850	6/30/13 18:00	0.998	0.52	12,955,515	986,425	33,915	6/30/13 18:00	0.997	0.53
Jul	5,654,440	605,210	13,430	7/3/13 17:00	0.994	0.57	16,694,930	2,067,530	40,130	7/3/13 17:00	0.992	0.56
Aug	4,953,610	391,330	11,340	8/19/13 18:00	0.997	0.59	14,678,725	1,543,250	32,525	8/19/13 18:00	0.995	0.61
Sep	4,414,920	222,560	11,390	9/11/13 18:00	0.999	0.54	13,093,540	867,220	33,020	9/11/13 18:00	0.998	0.55
Oct	4,729,890	82,440	9,260	10/29/13 9:00	1.000	0.69	14,035,910	199,255	27,190	10/29/13 9:00	1.000	0.69
Nov	5,337,400	88,130	11,690	11/22/13 9:00	1.000	0.63	15,840,995	170,385	33,800	11/22/13 9:00	1.000	0.65
Dec	7,273,860	190,350	15,100	12/9/13 9:00	1.000	0.65	21,246,780	394,135	43,490	12/9/13 9:00	1.000	0.66

Note: *Demand (kW) represents the peak coincident demand.

CHAPTER 7

POWER FLOW ANALYSIS

CHAPTER 7

POWER FLOW ANALYSIS

A. METHOD

The City of Ashland electrical distribution system was modeled based on the following data:

- The City's geographic information system (GIS) maps and data compiled during the study process including: updated records of conductor type, size, and phasing; transformer locations, kVA ratings and phase connections; fuse locations and ratings; sectionalizing schemes, regulators and capacitor devices with ratings and interconnection type; and switching location and status.

- BPA point-of-delivery meter data and Ashland SCADA data for the system, substations, feeders, and large industrial/commercial loads.

- The most recent coincidental feeder and system peak demand of 43.49 MW, occurring in December 2013 was used as the Base Case Peak Load criteria, Case 1A.

- For Case 1B, the Base Case Light Load condition, data from recent years was examined and a system load of 10.58 MW was modeled to recreate the conditions from May 5, 2013.

- In the five-year growth case, Case 2A, a system peak demand of 45.84 MW was modeled based on the load forecast projections in Chapter 3. This case includes some system improvements with added kVA allocations as detailed in Section C of this chapter.

- In the ten-year growth case, Case 2B, a system peak demand of 48.33 MW was modeled based on the load forecast projections from Chapter 3. Allocations of additional kVA are detailed in Section C of this chapter.

- To assess the loss of a substation transformer, the system was modeled under Base Case (1A) conditions with each substation power transformer individually removed from service and its load transferred to adjacent substation feeders. These transformer *out-of-service* models are evaluated and identified as Case 3-A, Case 3-OK1, 3-OK2 and Case 3-MA analyses.

- To assess the loss of a feeder, the system was modeled under Base Case (1A) conditions with each feeder circuit removed individually from service and its load transferred to adjacent feeder circuit(s). These feeder *out-of-service* models are evaluated and identified as Case 4 analyses with unique feeder suffixes.

- Power factor was matched to the observed power factor at each individual feeder for the peak cold weather event which occurred on December 9, 2013. This power factor was used for all cases.

- The voltage regulator on Oak Knoll Substation Bank #2 was set to match the Bank #1 transformer load tap changer at approximately 123 V on a 120 V base. The voltage regulators at Ashland Substation were set at 124.5 on a 120 V base. Finally, the Mountain Avenue Substation transformer load tap changer was set at 121.2 on a 120 V base.

All power flow system analyses have been configured based on the City's electric system maps and information, the EasyPower model can be found in Appendix D. The model bus names correspond to the junctions or interconnections matching the City's electric system. All power flow analyses were performed with the spot feeder loads scaled as necessary to simulate historic peak demand conditions, unless otherwise stated. Some loads were distributed across the various system sections proportionally to satisfy the peak conditions.

Table 7-1 lists the 50 largest energy users of 2013 with their average demand.

Table 7-1
Largest Industrial/Commercial Accounts by Peak Demand

	Business Name	Meter ID	Peak Demand (kW)	Date of Peak
1	SOU/Physical Plant Department	721431	2037	9/24/2013
2	SOU/Physical Plant Department	721429	1438	6/25/2012
3	Ashland Comm. Health Care System	721439	856	7/15/2013
4	City Of Ashland, Sewage Disposal Plant	721311	706	5/9/2013
5	OSFA	721353	576	2/5/2013
6	Caldera Brewing Co	721508	345	1/8/2013
7	SOU/Physical Plant Department	721134	344	2/14/2013
8	Ashland Springs Hotel	721466	330	1/7/2014
9	Varsity Theatre	720959	328	1/8/2013
10	Ashland Public Schools	721135	324	1/17/2012
11	National Fish & Wildlife	721427	314	8/6/2013
12	Albertsons Inc. #573	721425	310	7/25/2013
13	Emeritus Corporation	720840	302	1/6/2014
14	Safeway Stores Inc. #4292	721380	300	7/12/2013
15	Nspired Natural Foods	721435	283	9/24/2012
16	OSFA	720967	240	8/8/2012
17	Ashland Public Schools	721402	227	1/10/2014
18	Market Of Choice #11	721361	225	7/17/2013
19	Ashland Public Schools	721061	212	7/13/2012
20	Skylark Assisted Living LLC	721276	210	12/24/2013

Table 7-1
Largest Industrial/Commercial Accounts by Peak Demand

	Business Name	Meter ID	Peak Demand (kW)	Date of Peak
21	CenturyLink, Inc.	720742	208	4/27/2012
22	Hull Properties	721150	204	12/20/2013
23	Ashland Public Schools	721139	194	3/20/2012
24	Plaza Inn & Suites	720749	192	12/30/2013
25	City Of Ashland	721462	186	1/10/2012
26	OSFA	721354	172	7/8/2013
27	Ashland Food Cooperative	721358	169	8/1/2013
28	Independent Printing Co	721292	162	1/23/2013
29	Independent Printing Co	721255	147	4/23/2012
30	Ashland Public Schools	721397	145	10/24/2012
31	Ashland Shop N Kart	721443	142	2/22/2013
32	City Of Ashland, Service Ctr	720739	138	1/27/2012
33	Bi Mart	721175	134	8/26/2013
34	Ashland Shop N Kart	721449	131	8/26/2013
35	Ashland Public Schools	721491	130	10/9/2013
36	Ashland YMCA	721181	129	7/24/2013
37	Windsor Inn	721423	125	1/7/2014
38	Stratford Inn	721379	125	2/7/2012
39	Linda Vista-Prestige Care	721062	120	7/15/2013
40	Tpi/Rite Aid, Store # 5385 1408	721188	120	8/23/2012
41	OSFA	721355	117	8/9/2013
42	Ashland Public Schools	721404	109	10/10/2013
43	OSFA	720907	108	1/7/2014
44	Holiday Inn Express	720870	102	1/7/2014
45	SOU	721482	100	12/6/2012
46	Science Works	720836	92	1/3/2014
47	Jackson Co Library Sys	720718	89	8/28/2013
48	Mountain Meadows Homeowners Assoc.	721280	86	7/29/2013
49	OSFA	720916	83	7/8/2013
50	Standing Stone Brewing Co.	721373	76	9/7/2012

B. EVALUATING POWER FLOW RESULTS

In general, caution should be practiced when interpreting system problems indicated by the power flow analyses. Power flow results typically identify system problems such as heavily loaded or overloaded conductors and undervoltage conditions. The modeled conditions are the result of analysis under peak or other ‘worst case’ conditions that may be considered extreme. The goal is to evaluate system operation under realistic worst-case conditions. It is recommended that where problems are noted, the City should verify that the actual system components and conditions support the analysis conclusions.

Also, as with any model, the results will only be as accurate as the data used. For example, conductor sizes and materials, system component phasing, and interconnectivity are modeled using information from the City's GIS distribution system detail maps and correspondence with City staff. If there is inaccuracy in the map compilation or any parameter of the data characteristics, there will be inaccuracy in the results.

C. POWER FLOW CASE LOAD ALLOCATION AND RESULTS

CASE 1A. BASE CASE PEAK LOAD

The Base Case Peak Load power flow analysis was performed on the existing system configuration under the most recent peak load conditions which occurred on December 9, 2013. A demand of 43.49 MW was modeled based on load data from BPA metering and the City of Ashland SCADA system. This power flow model evaluates the system in its normal configuration with three distribution substations serving 10 feeder circuits.

The results of this analysis indicate that there are no conductor overload problems or low voltage conditions, defined as anything less than 95 percent of nominal bus voltage. However, the Ashland Substation transformer owned by PacifiCorp is loaded to 96.6% of its total fan cooled nameplate capacity (65 degree rise). The feeder loading (kW) and power factor from the power flow results of Case 1A are shown in Table 7-2.

Table 7-2
Base Case 1A Power Flow Details

Feeder Load	kW	PF (%)	Amps
A2000 - Business	5591	100.0%	259
A2001 - N. Main	5924	100.0%	274
A2002 - Railroad	2026	100.0%	94
A2003 - E. Nevada	0	100.0%	0
M3006 - N. Mountain	1001	100.0%	46
M3009 - Morton	6104	100.0%	283
M3012 - S. Mountain	4791	100.0%	222
M3015 - Wightman	2954	100.0%	137
5R56 - Hwy 99	6470	100.0%	300
5R70 - Hwy 66	4660	100.0%	216
5R93 - E. Main	3970	100.0%	184
Substation Load	**kW**		
Ashland	13241		
Mountain Ave.	15150		
Oak Knoll Bank 1	6470		
Oak Knoll Bank 2	8630		

CASE 1B. BASE CASE LIGHT LOAD

To determine representative conditions for modeling, BPA demand data was examined for typical light load conditions. A system demand of 10.58 MW, not including PacifiCorp load, was modeled based on data from May 2013. Load was distributed to each feeder using historical observations of both Ashland SCADA data and BPA data.

The results indicate that there are no conductor overload problems or high voltage conditions, defined as anything greater than 105 percent of nominal bus voltage. The feeder loading (kW) and power factor from the power flow results of Case 1B are shown in Table 7-3.

Table 7-3
Base Case 1B Power Flow Details

Feeder Load	kW	PF (%)	Amps
A2000 - Business	1480	100.0%	69
A2001 - N. Main	1339	100.0%	62
A2002 - Railroad	240	100.0%	11
A2003 - E. Nevada	0	100.0%	0
M3006 - N. Mountain	299	100.0%	14
M3009 - Morton	1543	100.0%	71
M3012 - S. Mountain	1165	100.0%	54
M3015 - Wightman	816	100.0%	38
5R56 - Hwy 99	1400	100.0%	65
5R70 - Hwy 66	1220	100.0%	56
5R93 - E. Main	1080	100.0%	50
Substation Load	**kW**		
Ashland	3059		
Mountain Ave.	3823		
Oak Knoll Bank 1	1400		
Oak Knoll Bank 2	2300		

CASE 2A. FIVE-YEAR GROWTH CASE

For the five-year growth case, the total load growth was based on data from Chapter 3. Five year developments and growth areas were discussed in depth with City staff, and the modeled allotment of new load to each feeder is listed in Table 7-4. The addition of these loads results in a combined peak load of 45.84 MW distributed as shown in Table 7-5.

Table 7-4
Five-Year Developments and Load Addition Expectations

Additional Load Description	Peak (kW)	Load Type	Feeder
Normal neighborhood development (West of Clay St.)	1000	Residential	5R93
New Apartment Complex	800	Residential	A2001
Meadowbrook neighborhood growth (Plum Ridge Ct.)	250	Residential	M3006
Residential and commercial fill	300	Residential/ Commercial	A2000, A2002, M3009, M3012, M3015, 5R56, 5R70
Total Additional Load	2350		

Table 7-5
Five-Year Growth Power Flow Details

Feeder Load	kW	PF (%)	Amps
A2000 - Business	5633	100.0%	263
A2001 - N. Main	6724	100.0%	293
A2002 - Railroad	2068	100.0%	85
A2003 - E. Nevada	0	100.0%	0
M3006 - N. Mountain	1251	100.0%	58
M3009 - Morton	6146	100.0%	301
M3012 - S. Mountain	4833	100.0%	226
M3015 - Wightman	2996	100.0%	141
5R56 - Hwy 99	6512	100.0%	304
5R70 - Hwy 66	4702	100.0%	220
5R93 - E. Main	4970	100.0%	230
Substation Load	**kW**		
Ashland	14425		
Mountain Ave.	15226		
Oak Knoll Bank 1	6512		
Oak Knoll Bank 2	9672		

The Five-Year Growth Case power flow results show that there are no conductor overload or low bus voltage conditions. However, the Ashland Substation transformer is loaded to 106.8% of nameplate fan cooled capacity and the A2001 circuit is above recommended loading guidelines established in Chapter 4. In the coming years during peak winter and summer conditions, the Ashland Substation transformer loading should be monitored and the City should consider shifting some loads from Ashland to Mountain Avenue Substation feeders.

CASE 2B. TEN-YEAR GROWTH CASE

Combined with the load additions for the five-year growth case, the Load Forecast presented in Chapter 3 calls for an additional 2.49 MW of peak demand growth. The modeled allotment of new load to each feeder is listed in Table 7-6. The addition of these loads results in a combined peak load of 48.33 MW distributed as shown in Table 7-7.

Table 7-6
Ten-Year Developments and Load Addition Expectations

Description	Peak (kW)	Load Type	Feeder
Additional Normal neighborhood development (West of Clay St.)	1000	Residential	5R93
Croman Mill beginning development	500	Industrial	5R56
Verde Village	300	Residential	A2001
Residential and commercial fill	690	Residential/ Commercial	A2000, A2002, M3006, M3009, M3012, M3015, 5R70
Total Additional Load.	2490		

Table 7-7
Ten-Year Growth Power Flow Details

Feeder Load	kW	PF (%)	Amps
A2000 - Business	5731	100.0%	268
A2001 - N. Main	7024	100.0%	307
A2002 - Railroad	2166	100.0%	89
A2003 - E. Nevada	0	100.0%	0
M3006 - N. Mountain	1349	100.0%	63
M3009 - Morton	6244	100.0%	306
M3012 - S. Mountain	4931	100.0%	231
M3015 - Wightman	3094	100.0%	146
5R56 - Hwy 99	7012	100.0%	327
5R70 - Hwy 66	4800	100.0%	225
5R93 - E. Main	5970	100.0%	276
Substation Load	**kW**		
Ashland	14921		
Mountain Ave.	15618		
Oak Knoll Bank 1	7012		
Oak Knoll Bank 2	10770		

The Ten-Year Growth Case power flow results show that there are no conductor overload or low bus voltage conditions. However, the Ashland Substation transformer is loaded to 111.2% of nameplate fan cooled capacity and the A2001 circuit is above recommended loading guidelines established in Chapter 4. During peak winter and summer conditions, the Ashland Substation transformer loading should be monitored and the City should consider shifting some loads from Ashland to Mountain Avenue Substation feeders.

D. SECTIONALIZED CASES

To evaluate the electric system's switching flexibility during outages and other abnormal conditions, power flow cases were performed under sectionalized conditions with the Base Case (Case 1A) loading. The following scenarios were analyzed:

- Individual substation transformer outages (Oak Knoll Bank #1, Oak Knoll Bank #2, Ashland, Mountain Avenue)
- Individual distribution feeder outages (10)

For each loss-of-substation scenario the system is configured as identified in Table 7-8, and for each individual feeder out-of-service condition the system is configured as identified in Table 7-9.

CASE 3. LOSS-OF-SUBSTATION TRANSFORMER CASES

GENERAL

The loss of each substation transformer is analyzed individually in the cases below, with distribution circuit loads assumed to be transferred to the transformers remaining in operation. The basis for he sectionalizing methods used in these simulations was developed through in-depth discussions with City staff. The four loss-of-substation transformer cases presented below are summarized in Table 7-8, with additional analysis results appearing in Appendix F.

CASE 3-A ASHLAND SUBSTATION OUT-OF-SERVICE:

The following system switching was modeled to simulate the necessary switching and transfer of Ashland substation load to other substation transformers.

- Close SW-1073 to tie A2001 to A2000, close SW-1064 to serve both A2000 and A2001 from M3006.
- Close SW-1068 to serve A2002 from M3009.

With the switching detailed above, all Ashland Substation load is transferred to Mountain Avenue Substation feeders. The Mountain Avenue Substation transformer is heavily overloaded to 145% of nameplate fan cooled capacity, the North Mountain Feeder is carrying 12.72 MW of load, and segments of conductor along the North Mountain Feeder are at capacity or overloaded as described below:

- The main 750 kcmil UG getaway is loaded to 119.5% of capacity.
- The section of 336.4 kcmil cable connecting M3006 to the Ashland Substation circuits is loaded to 100% of capacity.
- The section of 750 kcmil UG cable between E6603 and E8601 is overloaded to 111.2% of capacity.

In order to avoid accelerated loss of transformer life, some Mountain Avenue Substation load could be transferred to Oak Knoll Substation, but significant overload would still exist on the Mountain Avenue Substation transformer.

CASE 3-OK1 OAK KNOLL TRANSFORMER BANK #1 OUT-OF-SERVICE:

Using the auxiliary bus, the Hwy 99 Feeder load and additional PacifiCorp loads can be transferred to Oak Knoll Bank #2. Under the peak load conditions modeled, the Oak Knoll Bank #2 transformer (T-3856) is loaded to 94.8% of nameplate fan cooled capacity. No additional overload or low voltage conditions are encountered.

CASE 3-OK2 OAK KNOLL TRANSFORMER BANK #2 OUT-OF-SERVICE:

Using the auxiliary bus, the Bank #2 feeder loads can be transferred to Oak Knoll Bank #1. Under the peak load conditions modeled, the Oak Knoll Bank #1 transformer (T-3234) is overloaded to 119.6% of nameplate fan cooled capacity. No additional overload or low voltage conditions are encountered.

CASE 3-MA MOUNTAIN AVENUE SUBSTATION OUT-OF-SERVICE:

The following system switching was modeled to simulate the necessary switching and transfer of Mountain Avenue substation load to other substation transformers.

- Close SW-1062 to tie M3006 and M3012, and close SW-1064 to feed M3006 and M3012 from A2000.
- Close SW-1068 to feed M3009 from A2002.
- Close SW-1051 to feed M3015 from 5R93.

With the switching detailed above, the Ashland Substation transformer and regulators are severely overloaded to 160.8% and 121.7%, respectively, of nameplate fan cooled capacity under peak loading with Mountain Avenue Substation out-of-service. No additional overload or low voltage conditions are encountered.

SUBSTATION OUTAGE CONCLUSION

While significant improvements have been made since the last study, power flow modeling results show that the loss of Ashland or Mountain Avenue Substation transformers at peak load will lead to severe transformer overload conditions at other substations. The City might still be able to serve all load under these conditions, but it would risk accelerating the loss-of-life on overloaded transformers and cables.

As observed in the previous study, loss of Oak Knoll Substation Bank #2 causes Bank #1 to be overloaded, but the load does not exceed winter capacity rating at this time. In fact, with Bank #2 out-of-service at current peak load, Bank #1is loaded to 99.7% of winter capacity.

CASE 4. FEEDER OUTAGES

In the cases presented below and summarized in Table 7-9, each distribution feeder circuit is individually removed from service and its load is transferred to adjacent feeder(s). The sectionalizing methods used in these simulations come from in-depth discussions with City staff. Power flow analysis summary tables appear in Appendix F.

ASHLAND SUBSTATION

The cases below demonstrate the distribution switching options available for Ashland Substation feeders.

CASE 4-A2000 ASHLAND SUBSTATION – FEEDER A2000 OUT-OF-SERVICE:

System switching
Close SW-1073 to feed A2000 from A2001.

Results
Feeder A2001 is loaded to 11.566 MW, just above the recommended 11 MW with load transfer during planned outages or emergency situations. The Ashland Substation transformer is loaded to 97.3% of nameplate fan cooled capacity, and no undervoltage conditions are indicated.

CASE 4-A2001 ASHLAND SUBSTATION – FEEDER A2001 OUT-OF-SERVICE:

System switching
Close SW-1073 to feed A2001 from A2000.

Results
Feeder A2000 is loaded to 11.547 MW, just above the recommended 11 MW with load transfer during planned outages or emergency situations. Additionally, the 750 kcmil UG cable on A2001 between P7625 and E7551 is just above rated capacity and the Ashland Substation transformer is loaded to 97.4% of nameplate fan cooled capacity. No undervoltage conditions are indicated.

CASE 4-A2002 ASHLAND SUBSTATION – FEEDER A2002 OUT-OF-SERVICE:

System switching
Close SW-1068 to feed A2002 from M3009.

Results
No additional overload or undervoltage conditions indicated.

OAK KNOLL SUBSTATION

Oak Knoll Substation has an auxiliary bus that can be used to serve multiple feeders from a single substation recloser. For any single feeder outage, load can be transferred through the auxiliary bus to another feeder with no significant overload or undervoltage conditions. The cases below demonstrate the distribution switching options available.

CASE 4-5R56 OAK KNOLL SUBSTATION – FEEDER 5R56 OUT-OF-SERVICE:

System switching
Close SW-1039 to feed 5R56 from 5R70.

Results
No overload or undervoltage conditions indicated, however some of the main backbone conductor on the 5R70 (Hwy 66) feeder is heavily loaded (11.331 MW).

CASE 4-5R70 OAK KNOLL SUBSTATION – FEEDER 5R70 OUT-OF-SERVICE:

System switching
Close SW-1039 to feed 5R70 from 5R56.

Results
No overload or undervoltage conditions indicated, however some of the main backbone conductor on the 5R56 (Hwy 99) feeder is heavily loaded (11.364 MW) and transformer T-3234 is loaded to 101.9% of nameplate fan cooled capacity.

CASE 4-5R93 OAK KNOLL SUBSTATION – FEEDER 5R93 OUT-OF-SERVICE:

System switching
Close SW-1051 or SW-1052 to feed 5R93 from M3015.

Results
No overload or undervoltage conditions indicated. However, the Mountain Avenue substation transformer is at 94.9% of maximum force cooled capacity with this configuration.

MOUNTAIN AVENUE SUBSTATION

Mountain Avenue Substation has an auxiliary bus that can be used to serve multiple feeders from a single substation recloser. For any single feeder outage, load can be transferred through the auxiliary bus to another feeder with no significant overload or undervoltage conditions. The cases below demonstrate the distribution switching options available.

CASE 4-M3006 MOUNTAIN AVE SUBSTATION – FEEDER M3006 OUT-OF-SERVICE:

System switching
Close the SW-1062 to feed M3006 from M3012.

Results
No additional overload or undervoltage conditions indicated.

CASE 4-M3009 MOUNTAIN AVE SUBSTATION – FEEDER M3009 OUT-OF-SERVICE:

System switching
Close SW-1020 to feed M3009 from M3015.

Results
No additional overload or undervoltage conditions indicated.

CASE 4-M3012 MOUNTAIN AVE SUBSTATION – FEEDER M3012 OUT-OF-SERVICE:

System switching

Close SW-1062 to feed M3012 from M3006.

Results

No additional overload or undervoltage conditions indicated.

CASE 4-M3015 MOUNTAIN AVE SUBSTATION – FEEDER M3015 OUT-OF-SERVICE:

System switching

Close SW-1051 to feed M3015 from 5R93.

Results

No additional overload or undervoltage conditions indicated.

FEEDER OUTAGE CONCLUSION

The results show that under modeled peak conditions, the city should be able to transfer all of the load from any one feeder to an adjacent feeder successfully. However, transferring Ashland Substation feeders A2000 and A2001 at peak load will become problematic if additional load growth occurs on either feeder. Preferred switching for the Oak Knoll Circuits can result in heavily loaded backbone conductors and transformers, this situation should also be monitored as load growth occurs. Many of the overload conditions noted so far are well within the winter ratings of conductors and transformers, but recent data shows the City’s summer peak and winter peak can reach similar levels. As new load develops, the City will need to seek solutions to balance loads between feeders and potentially add more feeder circuits and transformation capacity to meet single contingency outage criteria.

Table 7-8

System Sectionalizing Analysis - Single Transformer Bank Outage

CASE	SUBSTATION	PEAK LOAD (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)
3-A	**Ashland***	**13,541**	**OUT-OF-SERVICE**	**13,507**	**13,507**	**25,405**
	A2000	5,591	To M3006	5,564	5,564	11,363
	A2001	5,924	To M3006	5,907	5,907	5,907
	A2002	2,026	To M3009	2,036	2,036	8,135
3-OK1	**Oak Knoll Bank #1***	**6,470**	**6,456**	**OUT-OF-SERVICE**	**15,026**	**6,456**
	5R56	6,470	6,456	6,454 (To Bank #2)	6,456	6,456
3-OK2	**Oak Knoll Bank #2**	**8,630**	**8,569**	**15,022**	**OUT-OF-SERVICE**	**11,611**
	5R70	4,660	4,653	4,652	4,653 (To Bank #1)	4,652
	5R93	3,970	3,916	3,916	3,917 (To Bank #1)	6,959
3-MA	**Mountain Avenue**	**14,850**	**28,578**	**14,795**	**14,795**	**OUT-OF-SERVICE**
	M3006	1,001	12,729	1,004	1,004	To A2000
	M3009	6,104	8,147	6,089	6,089	To A2002
	M3012	4,791	4,758	4,758	4,758	To A2000
	M3015	2,954	2,944	2,944	2,944	To 5R93

*PacifiCorp loads not included.

Table 7-9
System Sectionalizing Analysis - Loss-of Feeder Outage

CASE	PEAK LOAD (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)	SECTIONALIZED PEAK (kW)
Ashland*	**13,541**	**13,602**	**13,583**	**11,471**	**13,507**	**13,507**	**13,507**	**13,507**	**13,507**	**13,507**	**13,507**
4-A2000 Business	5,591	OUT-OF-SERVICE To A2001 Close SW-1073	11,547	5,564	5,564	5,564	5,564	5,564	5,564	5,564	5,564
4-A2001 N. Main	5,924	11,566	OUT-OF-SERVICE To A2000 Close SW-1073	5,907	5,907	5,907	5,907	5,907	5,907	5,907	5,907
4-A2002 Railroad	2,026	2,036	2,036	OUT-OF-SERVICE To M3009 Close SW-1068	2,036	2,036	2,036	2,036	2,036	2,036	2,036
Oak Knoll*	**15,100**	**15,025**	**15,025**	**15,025**	**15,247**	**15,280**	**11,108**	**15,025**	**15,025**	**15,025**	**18,067**
4-5R56 Hwy 99	6,470	6,456	6,456	6,456	OUT-OF-SERVICE To 5R70 Close SW-1039	11,364	6,456	6,456	6,456	6,456	6,456
4-5R70 Hwy 66	4,660	4,653	4,653	4,653	11,331	OUT-OF-SERVICE To 5R56 Close SW-1039	4,652	4,653	4,653	4,653	4,652
4-5R93 E. Main	3,970	3,916	3,916	3,916	3,916	3,916	OUT-OF-SERVICE To M3015 Close SW-1051	3,916	3,916	3,916	6,959
Mountain Avenue	**14,850**	**14,795**	**14,795**	**16,853**	**14,795**	**14,795**	**18,787**	**14,796**	**14,806**	**14,799**	**11,581**
4-M3006 N. Mountain	1,001	1,004	1,004	1,004	1,004	1,004	1,004	OUT-OF-SERVICE To M3012 Close SW-1062	1,004	5,766	1,004
4-M3009 Morton	6,104	6,089	6,089	8,147	6,089	6,089	6,089	6,089	OUT-OF-SERVICE To M3015 Close SW-1020	6,089	6,089
4-M3012 S. Mountain	4,791	4,758	4,758	4,758	4,758	4,758	4,758	5,763	4,758	OUT-OF-SERVICE To M3006 Close SW-1062	4,758
4-M3015 Wightman	2,954	2,944	2,944	2,944	2,944	2,944	6,936	2,944	9,044	2,944	OUT-OF-SERVICE To 5R93 Close SW-1051

*PacifiCorp loads not included.