City of Forest Grove Light & Power

ELECTRIC SYSTEM MASTER PLAN

Final Report – April 2022

Prepared for:

CITY OF FOREST GROVE LIGHT & POWER

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CITY OF FOREST GROVE LIGHT & POWER

ELECTRIC SYSTEM MASTER PLAN
FINAL REPORT

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1 INTRODUCTION

The City of Forest Grove selected Elcon Associates, Inc. to develop an Electric System Master Plan for the three Forest Grove substations and distribution system. This plan includes load forecasting analysis for future growth needs and review of the following:

1. Seasonal load shift data to identify areas of concern
2. Major electrical infrastructure replacement schedule
3. Distribution transformer inventory review and replacement schedule
4. Pole inventory review and replacement schedule
5. Underground cable inventory review and replacement schedule
6. Electric meter system replacement schedule and future system advisory
7. System situational awareness advisory

The City of Forest Grove provided Elcon Associates, Inc. with data for review and evaluation of the existing electrical distribution system including:

- Equipment inventories including transformers and poles for the distribution system
- Communication diagrams for the Filbert, Thatcher Junction, and Forest Grove Substations
- Underground cabling information for replacement
- Demographic and Income Profile
- Site Map
- Available Commercial & Industrial Sites as of August 2021
- Historic energy usage (kWh) data

Elcon Associates, Inc. was provided access to historic power use data for four meters, accessing aggregate hourly energy data from January 2013 through November 2021.

Data provided by TriAxis Engineering in the July 2013 Electric System Master Plan was also reviewed for this master plan, particularly the major infrastructure equipment.

2 SUMMARY AND RECOMMENDATIONS

This plan recommends replacing 829 distribution transformers, 1,359 poles, and 131 spans of underground in the distribution grid, and the main transformer and five feeder breakers as well as retiring three voltage regulators at Filbert substation. Criteria for replacing the listed equipment is found in the respective sections in this plan. Replacement would be implemented in the time frame of 10 years with consideration of priority, resource, and budget.

Given the estimated 0.96% total load growth rate and 1.13% peak load growth rate (see Section 3) and given the estimated 2-3 MW of additional load from the available commercial and industrial sites (see Section 3), the existing substations are capable of meeting the overall power demand growth in the next 10 years, with around 5-6 MW of surplus capacity. See Figures 3-2 and 3-3 for a visualization of the overall capacity of the Forest Grove system and projected average peak load over the next 10 years.

Because work has recently been completed on Forest Grove and Thatcher substations, the focus on major infrastructure equipment is on the Filbert substation. The main 15MVA power transformer needs replacement given its age. In addition, five 12.5kV feeder breakers warrant replacement, and the three voltage regulators warrant removal. An additional power transformer is not needed in the next 5 years but depending on future growth one may be needed in the next 10 years. See section 3 of this plan for further discussion.

For metering, this plan recommends replacing existing meters as they surpass their expected life expectancy. Advanced metering infrastructure (AMI) is recommended as a future metering system. See section 9 of this plan for further discussion on the current system and benefits of AMI.

This plan also recommends the City to upgrade its SCADA system to cope with future expansion in terms of functionality and security. More specifically, the four real-time automation controllers (RTAC) should be replaced with newer models. See section 10 of this plan for further discussion.

The Capital Improvement Plan (CIP) Budget shown in Table 2-1 is for a 10-year time frame. The replacement cost per year for distribution transformers, power poles, and 12.5kV underground cables can be found in their respective sections.

Table 2-1. Capital Improvement Plan Budget (10-Year Time Frame)

Distribution Grid	**Total**
Distribution Transformers Replacement Cost	$2,382,000
Utility Power Poles Replacement Cost	$16,515,000
12.5kV Underground Cable Replacement Cost	$3,010,000
Subtotal	$21,907,000
Filbert Substation	**Total**
Upgrade Cost	$3,500,000
Forest Grove & Thatcher Substations	**Total**
12.5kV Distribution Bay Upgrade Cost	$125,000
Overall Total	$25,532,000

3 LOAD FORECASTING FOR FUTURE GROWTH NEEDS

Total aggregated hourly energy data from the Forest Grove 1, Forest Grove 2, Thatcher Junction, and Filbert meters gives a 0.8% annual growth rate, or around 0.225 MWh/year. See Figure J-7 for a visualization of the average load increase per year. Figure 3-1 shows the actual historic total aggregated energy and a forecast projection based on low, medium, and high growth rate projections.

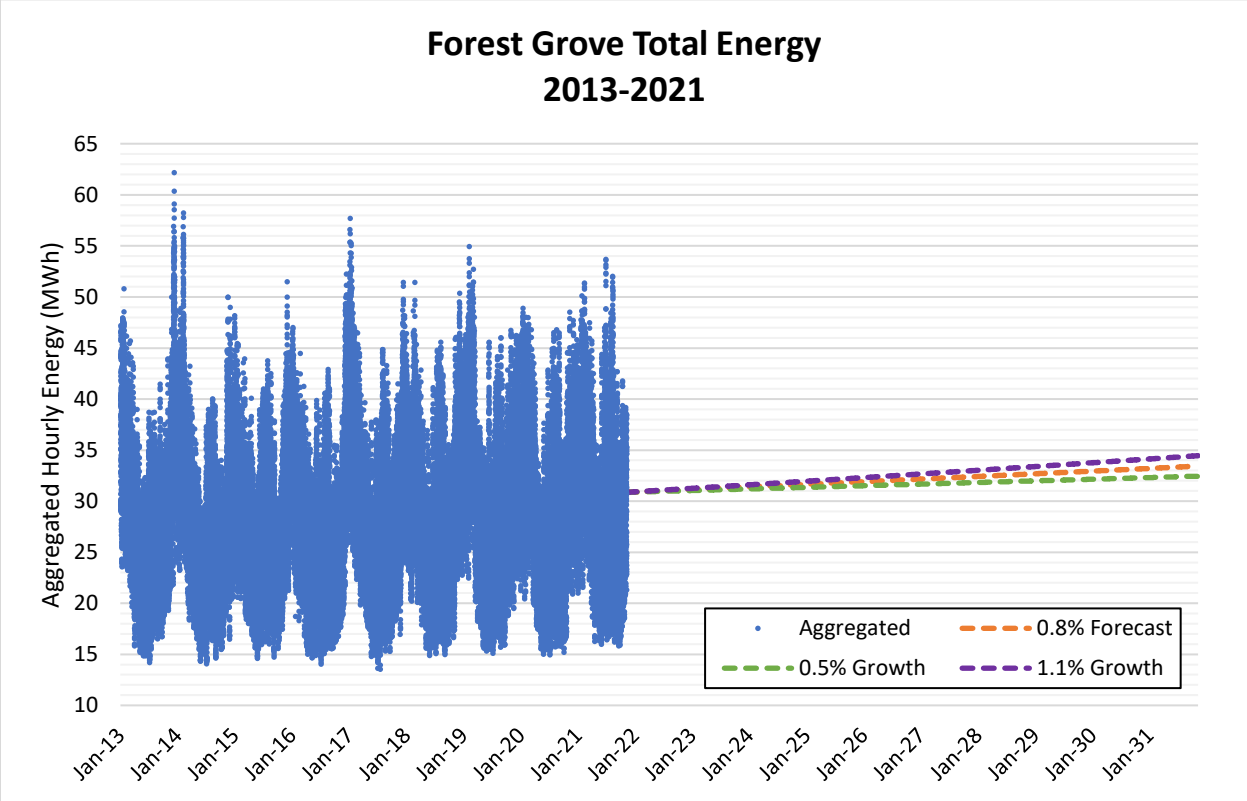

Figure 3-1. Total load historic data and total energy forecasts for the Forest Grove system.

See Appendix J for separate energy plots for each individual meter.

Figure 3-2 shows the average trend of the hourly energy for a 0.8% average growth rate. Note that the 0.8% forecast is only displaying average values. This does not consider infrequent peak loads, as seen with the aggregated portion of the chart.

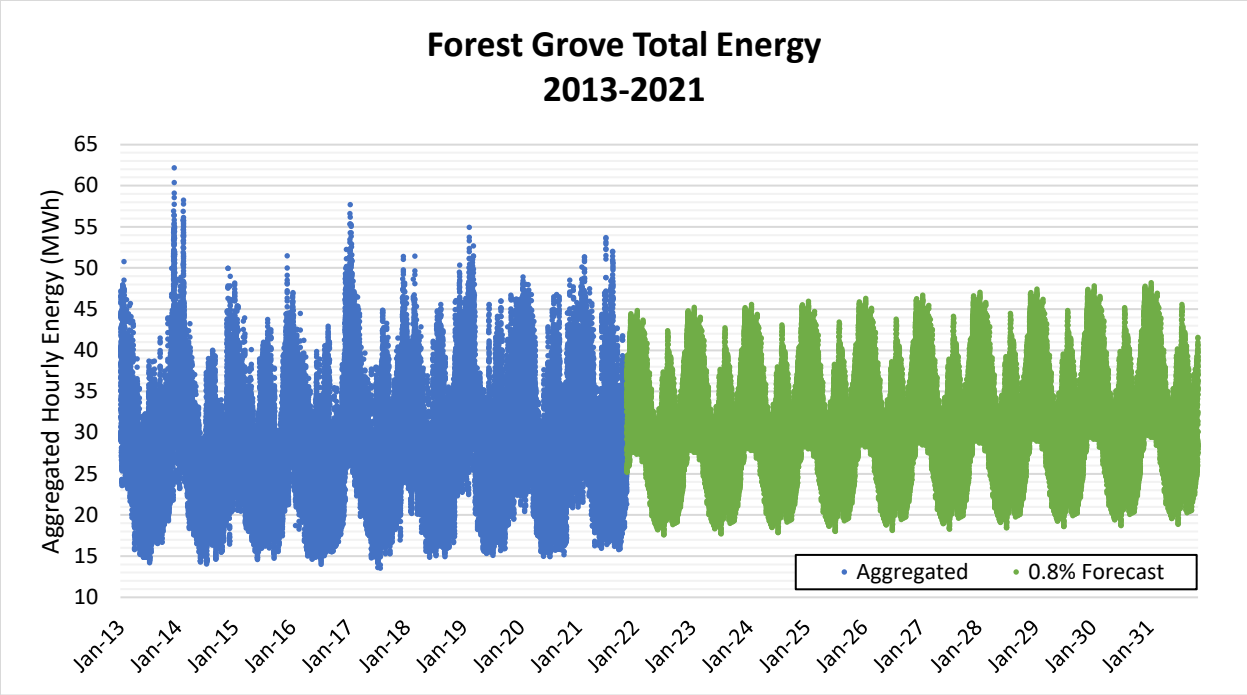

Figure 3-2. Total load historic data and 0.8% total energy forecast for the Forest Grove system.

The Forest Grove system must be able to handle peak loads, given that these are the highest values the equipment experiences. Figure 3-3 shows the actual historic average annual peak load and a forecast projection based on low, medium, and high growth rate projections.

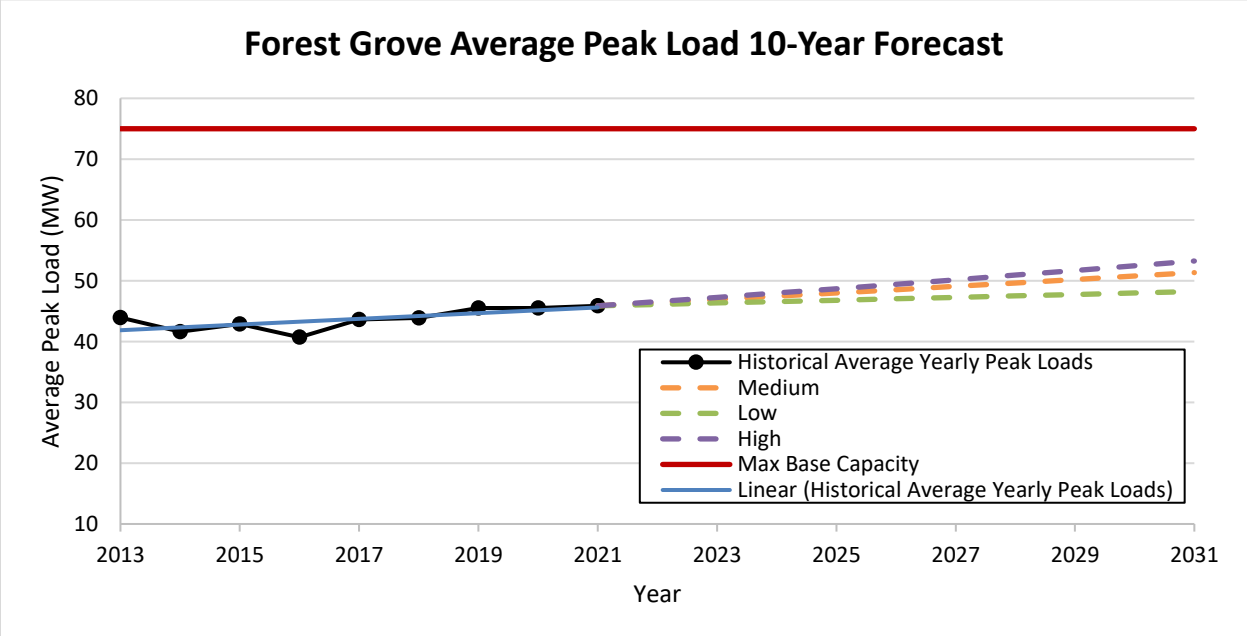

Figure 3-3. Average peak load historic data and total demand forecasts for the Forest Grove system, along with the maximum base capacity of all substation transformers (3-20MVA transformers and 1-15MVA transformer).

The table below summarizes the data after 5 years and 10 years for the low, medium, and high growth rates. Note that the medium growth rate is the annual growth rate based on the historic data from 2013-2021. Values in Table 3-2 are derived from the three growth percentages.

Table 3-2. Study Average Peak Load Forecast Summary.

Growth Rate	Base Case 2021 Average Peak Load (MW)	2026 Average Peak Load (MW)	2031 Average Peak Load (MW)
Low (0.5%)	45.5	47.0	48.2
Med (1.13%)	45.5	48.5	51.3
High (1.5%)	45.5	49.4	53.2

Figure 3-4 shows the historical monthly peak demand of the Forest Grove system, along with the projected monthly peak demand through 2031. The maximum base capacity of 75 MW of the Forest Grove system is also displayed in the chart.

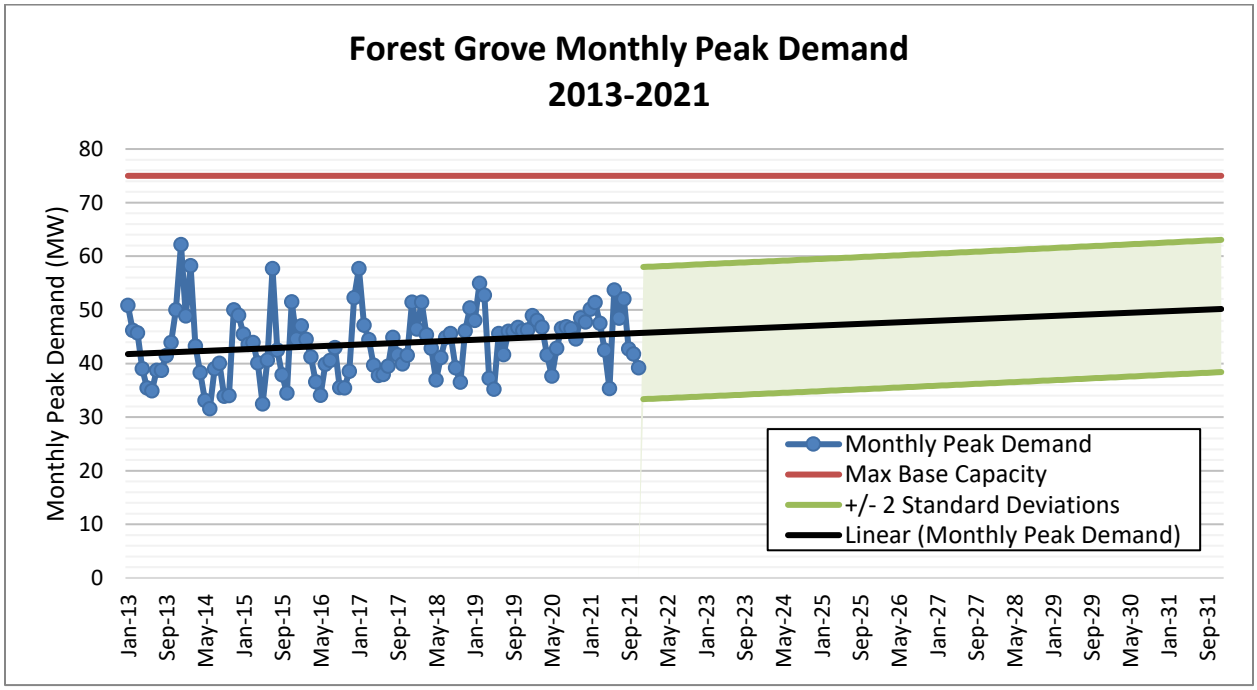

Figure 3-4. Monthly peak demand for the Forest Grove system from 2013-2021, along with the maximum base capacity of all substation transformers (3-20MVA transformers and 1-15MVA transformer) and projected peak demand. The green band represents +/- 2 standard deviations, or 95% of all data, from the average trend.

Looking at the green band of projected peak demand, there will be an expected 8 MW of surplus capacity (75 MW – 63 MW) in 10 years. The 63 MW value is 2 standard deviations above the average peak demand of 51.3 MW. It is important to consider this since monthly peak demand has surpassed 60 MW more than once historically.

Population

Forest Grove's Demographic and Income Profile prepared by esri indicates an average annual population growth rate for the area of Forest Grove of 1.5% for the 2020-2025 period. Yearly population data for figure 3-5 was obtained from the World Population Review. Figure 3-5 shows the correlation between the monthly total power load and population. From this, the overall trend in total load positively correlates with the growth in population.

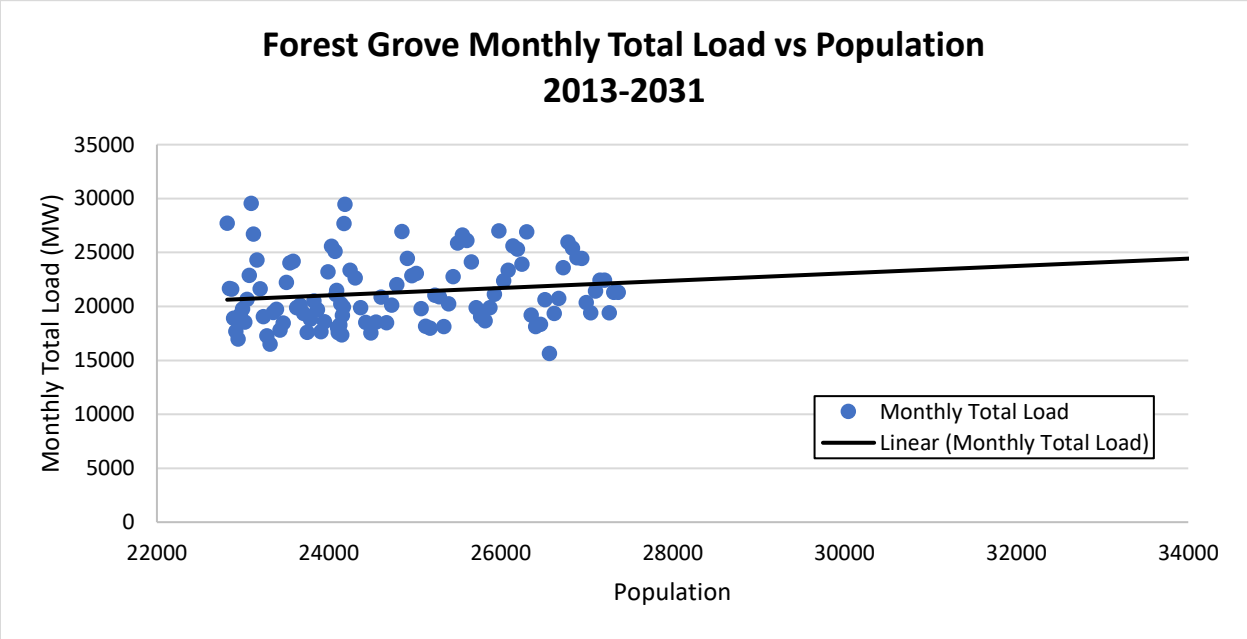

Figure 3-5. Total monthly load correlated with population for the Forest Grove system.

Given the slight positive trend in total energy in Figure 3-1, average peak power demand seen in Figure 3-3, and monthly peak demand seen in Figure 3-4, an additional transformer or transformer upgrade is not recommended. However, if for whatever reason peak loads and future growth exceeds the projections set forth in Figures 3-1, 3-3, and 3-4, then an additional substation could be discussed at that time.

Because citywide peak load has increased at an average annual rate of 1.13% from Figure 3-3 and Table 3-2, the average peak load is projected to be 48.5 MW in 5 years and 51.3 MW in 10 years. With the current base capacity at 75 MW, this will leave the Forest Grove system with an average of 23.7 MW surplus of capacity in 10 years. Referring back to Figure 3-4, the upper-bound (2 standard deviations above the average) peak demand will be 63 MW. This yields an 8 MW surplus of capacity in 10 years. If higher-than anticipated growth occurs north of the city, then either a second transformer should be added to Thatcher Substation, or an additional substation should be added, depending on the power requirement. Otherwise, the distribution system should be more than capable of supplying the increased load over the next 10 years.

Figure 3-6 illustrates the three existing substations and all the currently available commercial/industrial sites (locations likely to experience growth).

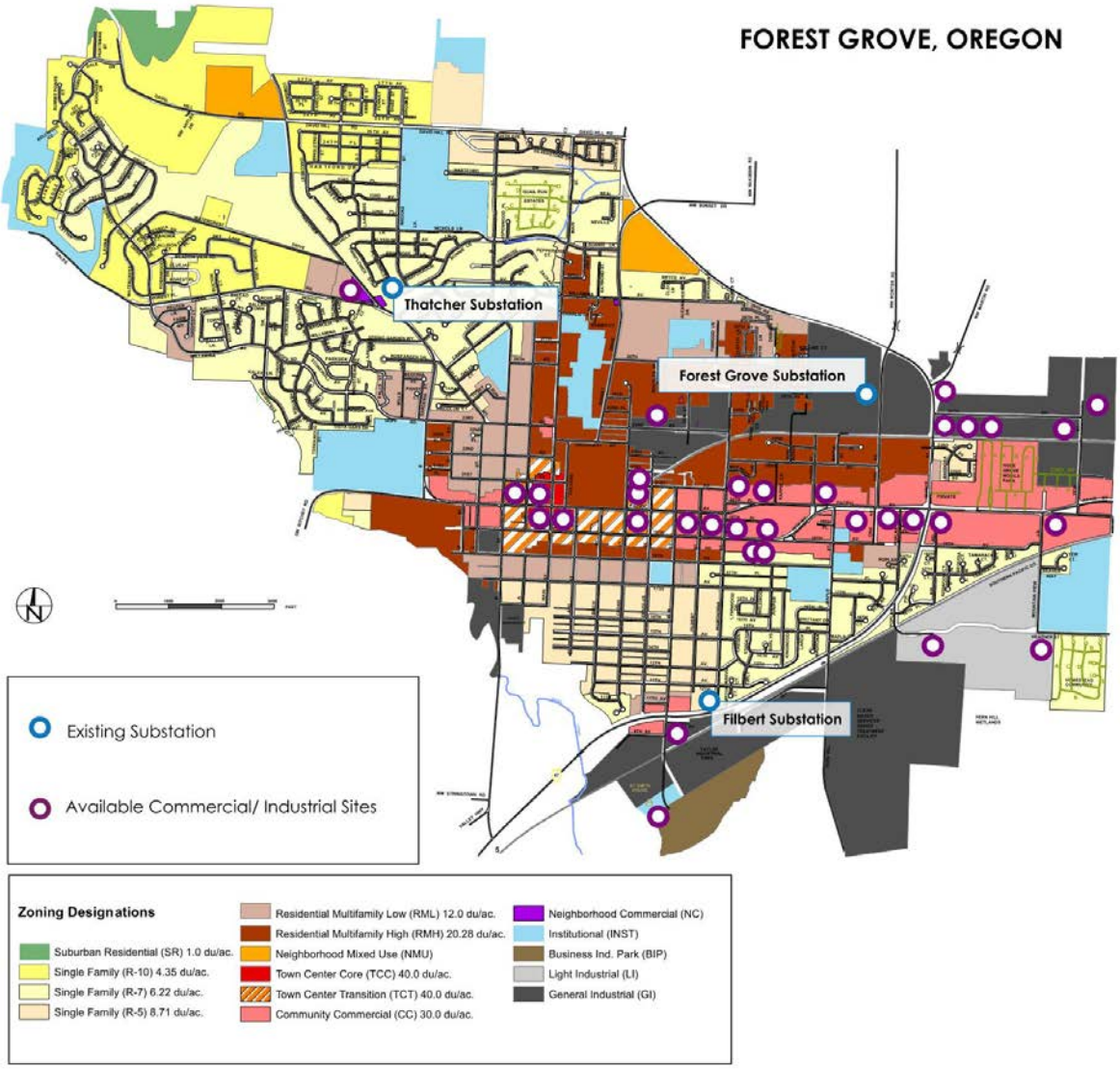

Figure 3-6. Zoned map of Forest Grove, showing locations of the existing substations (blue) as well as locations likely to experience growth (purple).

Based on the zoning of those available commercial/industrial sites, most of the power demand growth will be concentrated in central Forest Grove and the east side of Forest Grove. If all available commercial/industrial sites were leased or built, an additional 2-3 MW will be added to the citywide load. Subtracting this from the 8 MW of available peak capacity in 2031, there is still a projected peak of 5-6 MW of available capacity. See Appendix H for maximum energy usage of each available site.

4 SEASONAL LOAD SHIFT DATA

Weather data was provided by the Forest Grove (FOGO) weather station from the Bureau of Reclamation's AgriMet. In comparing average monthly load to mean monthly temperature, the graph below shows a strong correlation between high power demands during winter cold temperatures and summer hot temperatures. This graph not only suggests that the citywide load is weather-sensitive, but that it is historically winter-peaking.

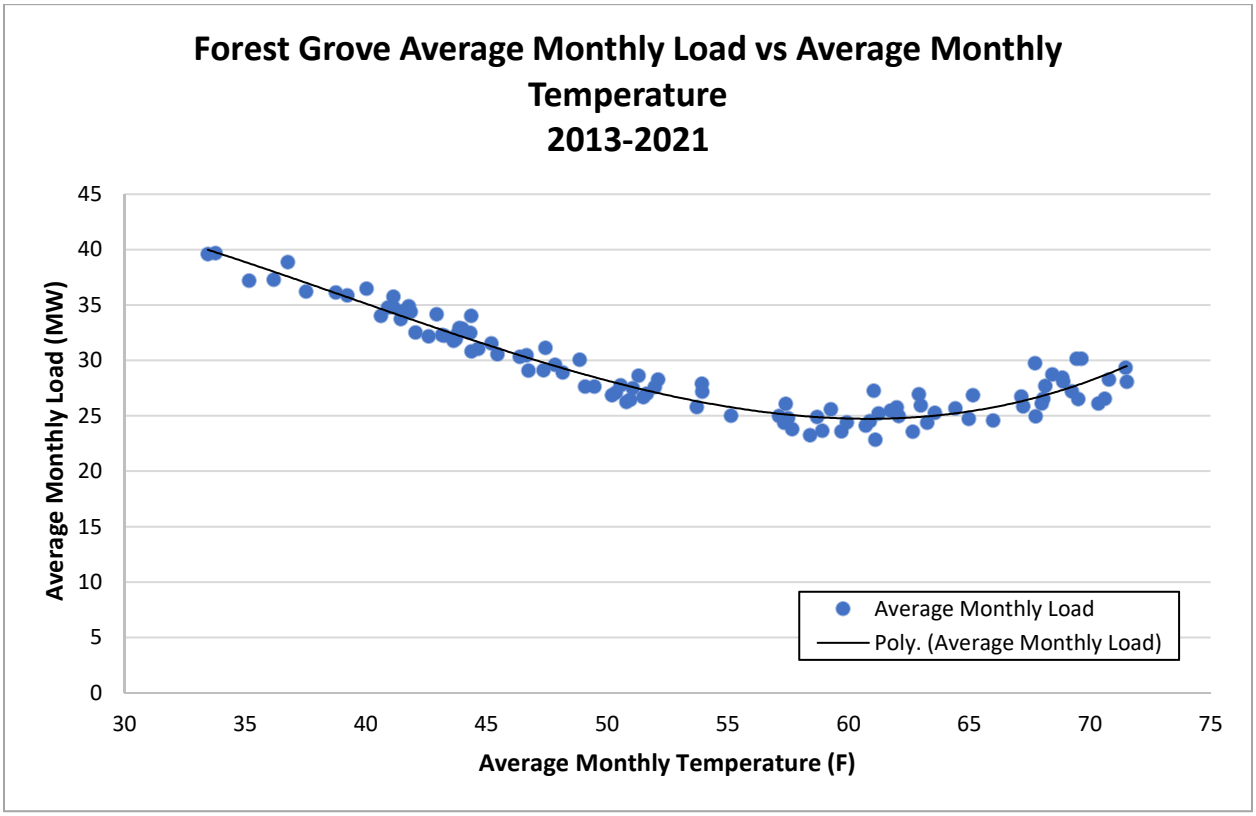

Figure 4-1. Average monthly load correlated with average monthly temperature for the Forest Grove system. A polynomial trendline visualizes the relationship between average monthly load and temperature.

The graph below depicts the relationship between hourly energy and hourly average temperature for the years 2013 and 2021. The same trend here matches that of the graph above, further suggesting that Forest Grove is winter peaking.

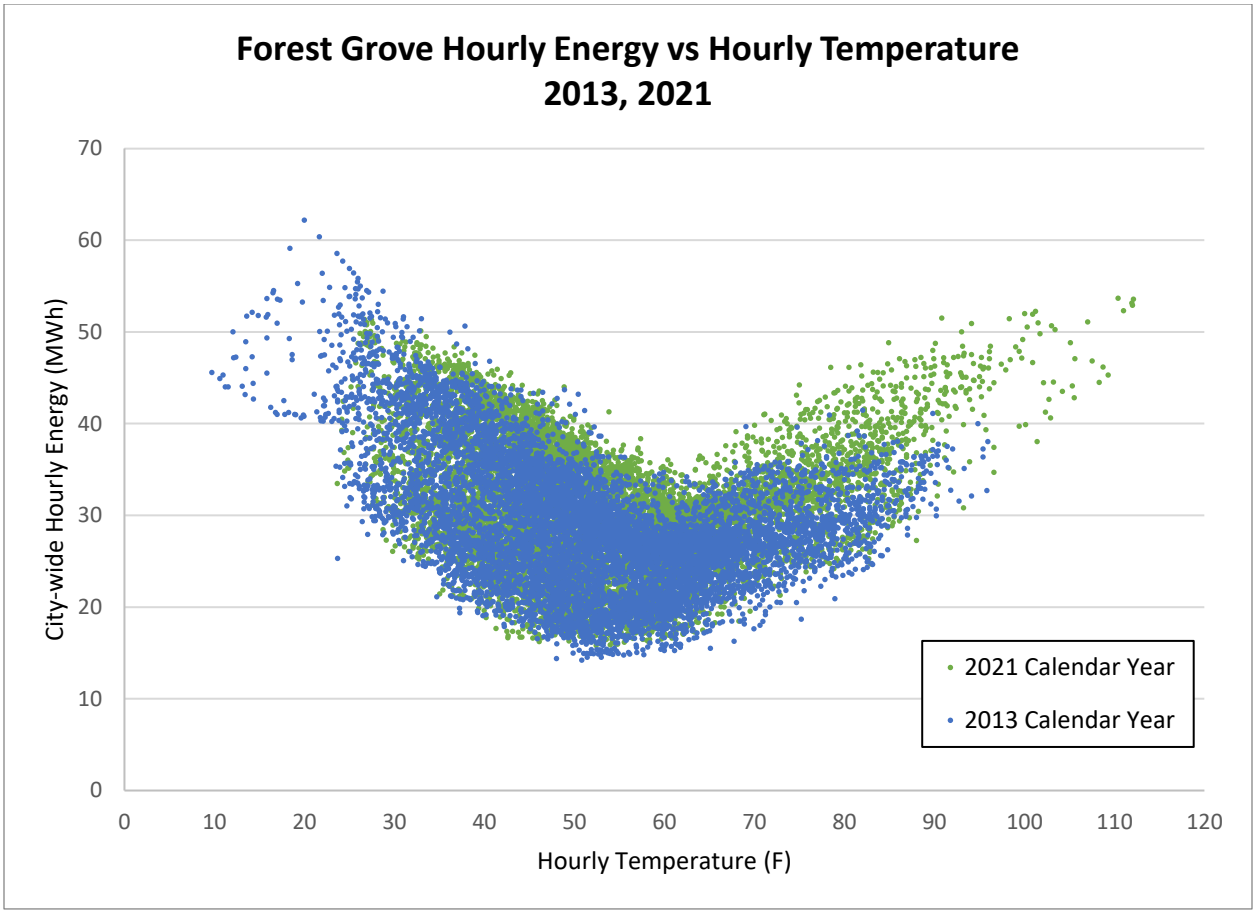

Figure 4-2. Hourly energy correlated with hourly temperature for 2013 and 2021 for the Forest Grove system.

Although it can be argued that Forest Grove is transitioning from a winter-peaking utility to a summer-peaking utility by noting that the highest values occurred with warmer temperatures in 2021 and with cooler temperatures in 2013 from Figure 4-2, there is not enough data to support this claim without more detailed analysis and continued tracking of load and weather trends. Looking at total hourly energy versus hourly temperature for each year individually from 2013-2021, 2021 is the only year showing Forest Grove as summer-peaking.

The combined scatter plots below in Figure 4-3 show the correlation between the monthly peak demand and the summer (May-September) high temperatures and winter (November-April) low temperatures. From this, it is clear that cooler temperatures in the winter and warmer temperatures in the summer correlate with higher citywide peak demand.

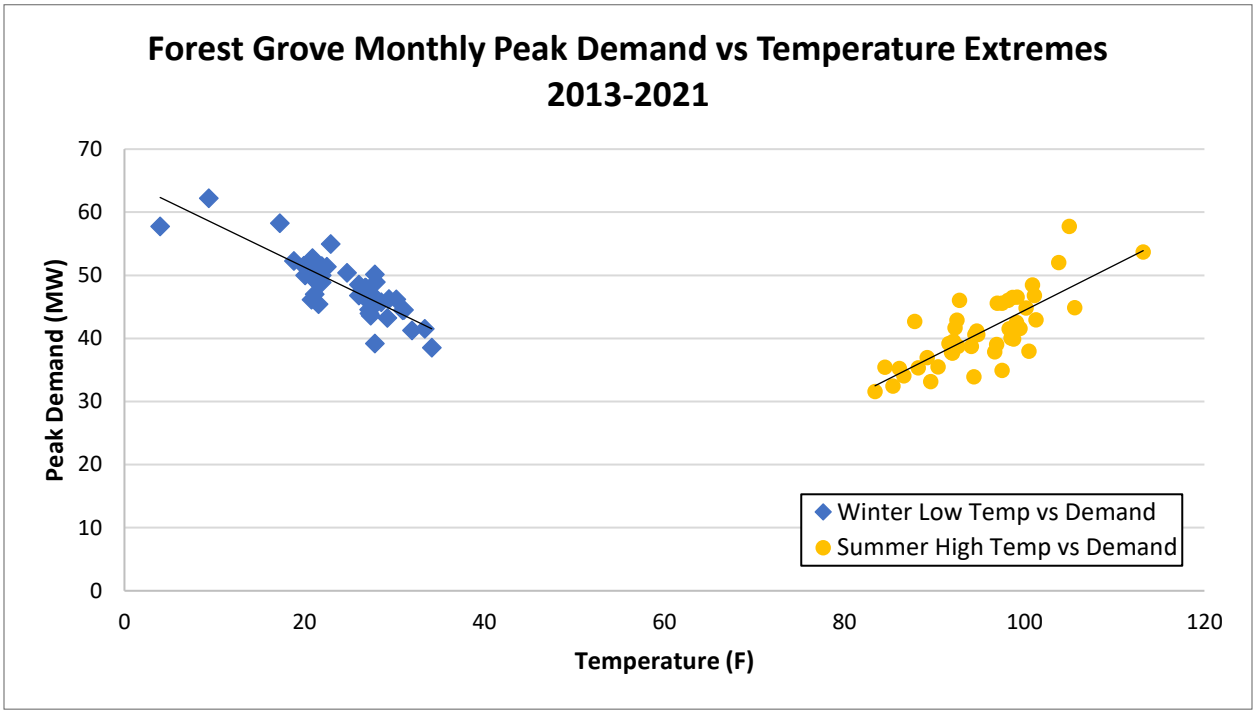

Figure 4-3. Monthly peak demand correlated with winter low temperatures and summer high temperatures from 2013-2021 for the Forest Grove system.

Optimal Substation Transformer Rating

Since Forest Grove is historically winter peaking, it is important to note that according to ANSI/IEEE C57.12, the thermal rating of substation transformers increases about 1% for each 1C that the average ambient temperature is below 30C. Substation transformers are rated for operation at 30C (86F) ambient, yet Forest Grove peak loads occur when ambient is below 0C (32F). Thus, during peak loads, when ambient temperature is 0C (32F), the total substation transformer base rating with the three existing substations is around 97.5 MVA ([1.3 x 3 transformers x 20 MVA] + [1.3 x 1 transformer x 15 MVA]) and single-contingency rating (loss of one transformer) is around 129.5 MVA ([1.3 x 2 transformers x 37.3 MVA] + [1.3 x 1 transformer x 25 MVA]) with ONFA2 ratings. These two ratings are thus significantly more than the nominal combined transformer rating 75 MW (at 30C) with the four substation transformers. In other words, the increase in power demand is accommodated by the increased power rating of the transformers in the colder temperatures. Table 4-1 outlines the ratings for the different ambient temperatures.

Table 4-1. Total base rating and single contingency rating at 0C and 30C for the Forest Grove system.

	0C (32F) Ambient Temperature	30C (86F) Ambient Temperature
Base Rating (MVA)	97.5	75
Single Contingency Rating (MVA)	129.5	99.5

5 MAJOR ELECTRICAL INFRASTRUCTURE REPLACEMENT SCHEDULE

Major electrical infrastructure includes power transformers, voltage regulators, 12.5kV circuit breakers, and 115kV circuit switchers. Filbert substation is the focus for infrastructure replacement in this master plan, since upgrades for the substation equipment at the Forest Grove and Thatcher substations have already taken place.

Data provided by the City of Forest Grove was assembled into the following table. Estimates of remaining life were developed using common utility industry equipment life estimates: 40 years for power transformers, 30 years for circuit breakers, and 20 years for 12.5 kV voltage regulators. Substation equipment life expectancy is very difficult to determine, and it depends on many factors including historic maintenance, local environment, loading history, typical operating temperatures, available fault current, and the number of operations or through faults; as a result, typical values are used for comparison only. Below is a table of critical equipment and their remaining life for the Filbert Substation. See Appendix F for equipment summaries of the other two substations – Forest Grove and Thatcher.

Table 5-1. Filbert substation equipment summary.

Equipment number	Manufacturer	Model number	Year of manuf.	Description	Age (Yrs)	Remaining Life (Yrs)
Filbert Sub						
FB T1	Hevi- Duty	5473324T00	1983	Power transformer	39	1
FB-1501	Mitsubishi	100-SFMT-40E-1	2020	Feeder breaker	2	28
FB CS-1	Southern States	CSV	2020	Circuit switcher	2	28
FB-1251	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1206	ABB	R-1	1999	Feeder breaker	23	7
FB-1208	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1209	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1210	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1241	ABB	RMAG	2005	Main breaker	17	13
FB RG-1 (A)	Siemens	JFR	*1993	Voltage regulator	29	-9
FB RG-1 (B)	Siemens	JFR	*1993	Voltage regulator	29	-9
FB RG-1 (C)	Siemens	JFR	*1993	Voltage regulator	29	-9

As shown in the equipment summary tables for Forest Grove and Thatcher substations in Appendix F, the equipment for these two substations were manufactured around 2015 or 2017 with an average equipment remaining life of about 25 years. Hence, the Filbert 12.5 kV distribution feeder breakers that have already exceeded their life expectancy require replacement soon to continue maintaining safe and reliable operations of the City utility systems. Additionally, the Filbert voltage regulators will need to be retired as the power transformer replacement will be equipped with modern load tap changers.

Below is a 10-year replacement schedule for the critical equipment at Filbert Substation.

Table 5-2. Filbert substation 10-Year Replacement Schedule.

Year	Description
2022	FB-1251, FB-1208, FB-1209, FB-1210
2023	FB T1 (retiring FB RG-1 (A), FB RG-1 (B), FB RG-1 (C))
2029	FB-1206

Filbert Substation Equipment Condition and Estimated Remaining Life:

Power Transformer (115kV – 12.5kV)

The Hevi-Duty Transformer (Serial Number GM 353876) still has one more year before reaching the life span of 40 years. Because peak power demand is increasing on average of 1.13%, as shown in section 3 of this master plan, a replacement of the existing transformer with a new unit will be sufficient. Referring to Figure J-4, the power demand at Filbert substation has been below 15 MVA on average the whole time from 2013-2021. Even if demand is higher for this substation, the other two substations can offset some of the load, given the 5-6 MW surplus of capacity mentioned at the end of Section 3. No additional transformer needs to be added to this substation.

12.5kV Voltage Regulator

Voltage regulators are mechanical devices with load-carrying switches in oil. These devices require periodic maintenance and special care when switching into and out of service. Though Forest Grove substations are designed to accommodate voltage regulators, consideration should be given to provide new transformers with modern load tap changers to simplify maintenance and operation.

The existing single-phase voltage regulators are Siemens Type JFR, manufactured in 1993. The manufacture's SS number for A phase is 6587-6; B phase is 6520-9; C phase is 6422-7. They have passed their 20-year life span and need to be retired.

115kV Circuit Switchers

The Southern State Circuit Switcher with Serial Number CV 12628 was recently installed in 2020 and will not be included in the replacement schedule.

12.5kV Feeder Breakers

Most of the 12.5kV feeder breakers at Filbert Substation are Westinghouse R-1 Vacuum-type breakers. These breakers were manufactured in April 1984. With a 30-year lifespan, these are 38 years old and therefore need to be replaced. The other two feeder breakers, FB-1501 and FB-1241 were manufactured in 2020 and 2005, respectively, and thus do not need replacement.

Forest Grove and Thatcher Substation Equipment Condition:

12.5 kV Distribution Bay

The City of Forest Grove confirmed that the last upgrade completed at Forest Grove and Thatcher substations only covered the critical components excluding the replacements of the existing main bus and the associated disconnect switches, and the overhead double 795 ACSR conductors in the 12.5kV distribution bay. The additional required replacements need to be included in the upgrade program recommended in this 2022 Master Plan.

The City considers the importance of upgrading the existing 12.5kV, 1200A bus and its associated disconnect switches to 2000A rated capacity because the new 20 MVA transformer at Forest Grove and Thatcher substations are furnished with an ONFA2 rating of 37.3MVA with a maximum full load current of 1723A. This requires replacing the 1.5 in. copper tubular bus with a 3 in. aluminum tubular bus.

IEEE Std. 605 – Guide for Bus Design in Air Insulated Substations has been applied to evaluate the ampacity and the short circuit current of the 3 in. aluminum tubular bus. The calculations can be found in Appendix E and the results are summarized as below:

Maximum Full Load Current (Transformer ONFA2 rating, 37.3MVA) at 12.5kV	1723A
Calculated Ampacity for 3 in Aluminum Tubular Bus (IEEE Std. 605)	2437A

Maximum Fault Current (Transformer 20MVA Base) with IZ=6% at 12.5kV	15.4kA
Calculated Short Circuit Current for 3 in. Aluminum Tubular Bus (IEEE Std. 605)	261kA

The overhead double 795 ACSR air conductors feeding from the new main breaker bays to the distribution bays also need to be replaced with the 3 in. aluminum tubular bus.

6 DISTRIBUTION TRANSFORMER INVENTORY REVIEW AND REPLACEMENT SCHEDULE

Distribution transformer equipment life expectancy is very difficult to determine and depends on many factors including historic maintenance, local environment, loading history, typical operating temperatures, available fault current, and the number of operations per through faults; as a result, typical values are used for comparison only. Estimates of remaining life were developed using common utility industry equipment life estimates: 50 years for liquid-filled distribution transformers.

Distribution transformer data provided by the City of Forest Grove indicates that 370 distribution transformers need to be replaced as of 2021, Taking the next 10 years into account, 829 distribution transformers need to be replaced over ten years.

The detail in cost in terms of materials, installation, and equipment are tabulated in Appendix C. Below is a 10-year replacement schedule for the distribution transformers needing replacement. The number of transformers needing replacement from Table C-1 differ from year to year in order to maintain the same total cost each year.

Table 6-1. 10-Year Distribution Transformer Replacement Schedule.

Year	Description	Cost
2022	24 Transformers from Table C-1, All Transformers from Table C-2	$186,108
2023	53 Transformers from Table C-1, All Transformers from Table C-3	$205,905
2024	39 Transformers from Table C-1, All Transformers from Table C-4	$248,176
2025	62 Transformers from Table C-1, All Transformers from Table C-5	$198,946
2026	54 Transformers from Table C-1, All Transformers from Table C-6	$220,243
2027	50 Transformers from Table C-1, All Transformers from Table C-7	$204,892
2028	17 Transformers from Table C-1, All Transformers from Table C-8	$302,743
2029	83 Transformers from Table C-9	$300,573
2030	54 Transformers from Table C-1, 20 Transformers from Table C-9, All Transformers from Table C-10	$266,670
2031	42Transformers from Table C-1, All Transformers from Table C-11	$247,189
Estimated Construction Cost (Rounded)		**$2,382,000**

Below is a bar graph depicting the number of distribution transformers by age, along with the number of distribution transformers by kVA rating.

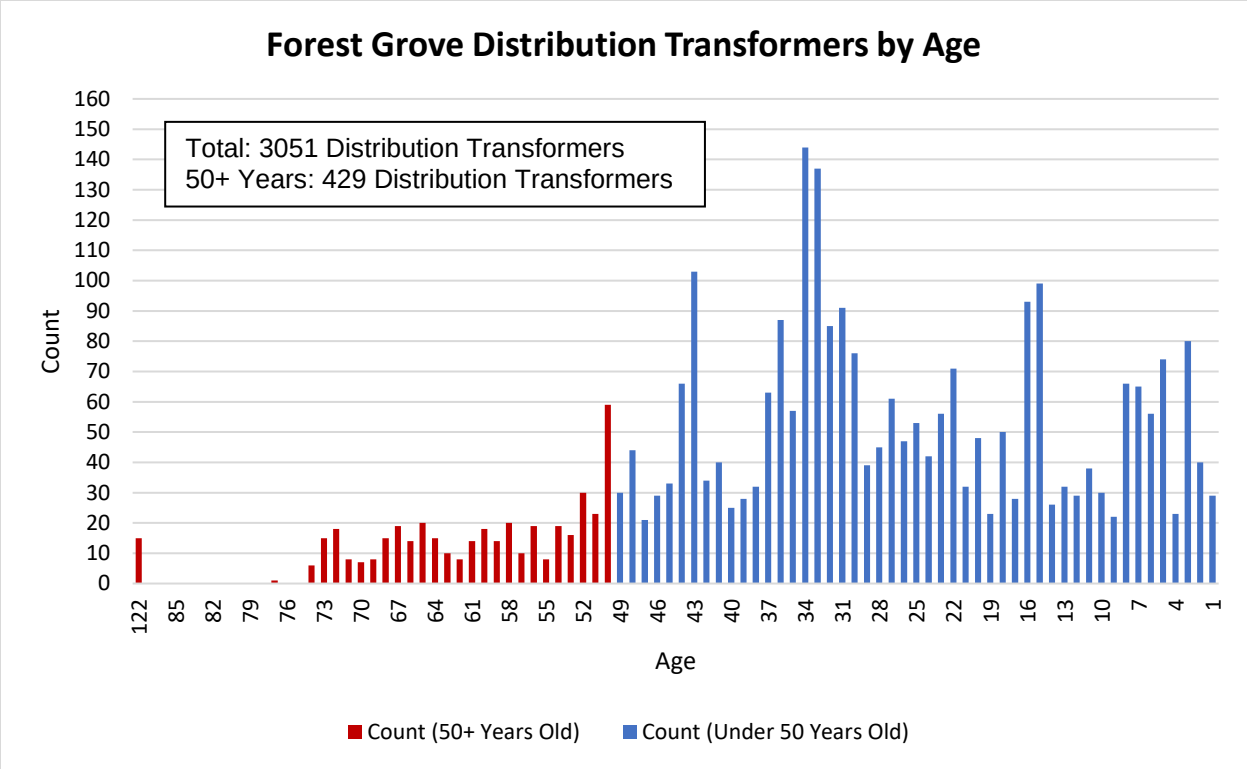

Figure 6-1. Number of distribution transformers by age.

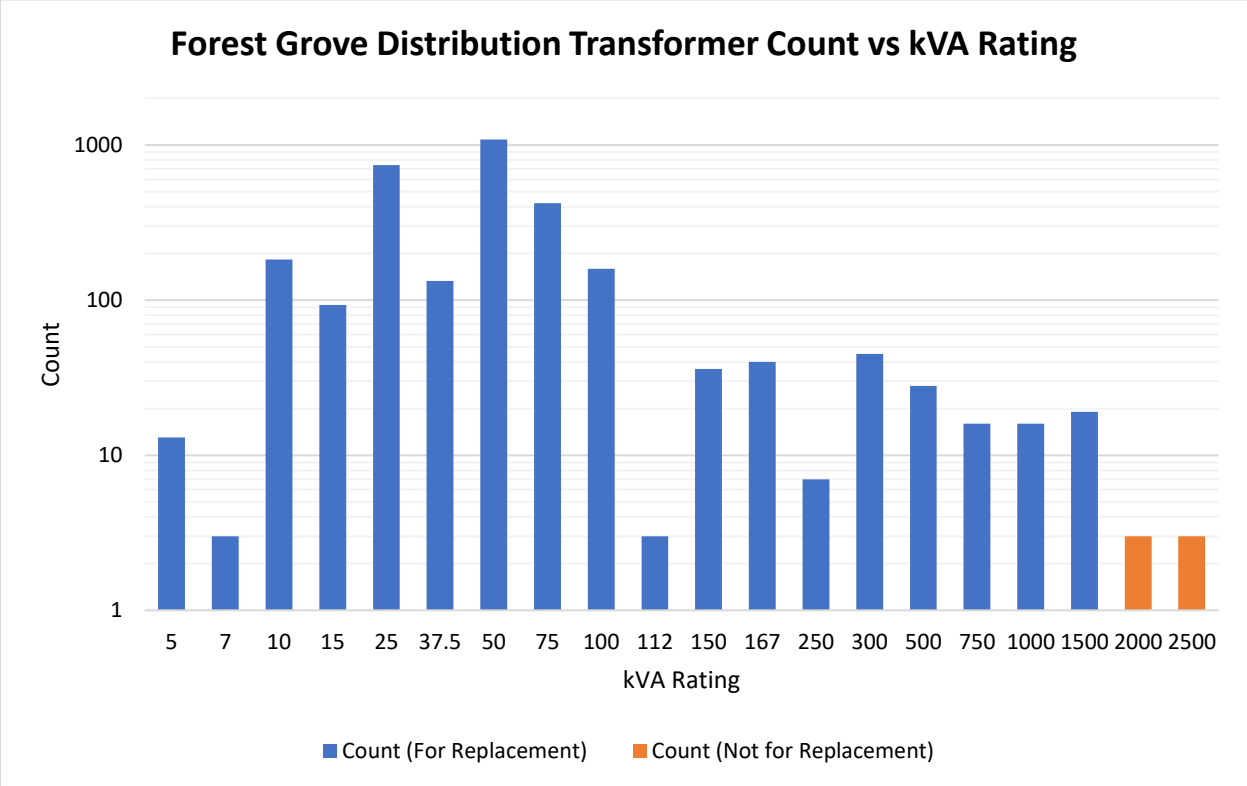

Figure 6-2. Number of distribution transformers by kVA rating. Note that the 3 2000-kVA and 3 2500-kVA distribution transformers do not need replacement, given their age.

7 POLE INVENTORY REVIEW AND REPLACEMENT SCHEDULE

Utility wood pole service life depends on many factors including historic maintenance, local environment, wood species and treatment details; as a result, typical values are used for comparison only. Therefore, estimates of remaining life were developed using common utility industry equipment life estimates: 55 years assuming they are not well-maintained. Pole data provided by the City of Forest Grove indicates that 827 poles are more than 55 years old as of 2021. Taking the next 10 years into account, 1,359 poles need replacement by 2031.

The detail in cost in terms of materials, installation, and equipment are tabulated in Appendix D. Below is a 10-year replacement schedule for the poles needing replacement. The number of poles needing replacement from Table D-1 differ from year to year in order to maintain the same total cost each year.

Table 7-1. 10-Year Poles Replacement Schedule.

Year	Description	Cost
2022	92 Poles from Table D-1, All Poles from Table D-2	$1,655,135
2023	75 Poles from Table D-1, All Poles from Table D-3	$1,652,415
2024	78 Poles from Table D-1, All Poles from Table D-4	$1,652,071
2025	56 Poles from Table D-1, All Poles from Table D-5	$1,649,256
2026	64 Poles from Table D-1, All Poles from Table D-6	$1,646,007
2027	64 Poles from Table D-1, All Poles from Table D-7	$1,650,007
2028	85 Poles from Table D-1, All Poles from Table D-8	$1,652,603
2029	113 Poles from Table D-1, All Poles from Table D-9	$1,659,732
2030	105 Poles from Table D-1, All Poles from Table D-10	$1,655,981
2031	95 Poles from Table D-1, All Poles from Table D-11	$1,641,792
Estimated Construction Cost (Rounded)		**$16,515,000**

Given the cost information presented in Appendix D and number of poles greater than 55 years old, $16,515,000 is required to replace the 1,359 poles. Below is a graph depicting the number of poles by year.

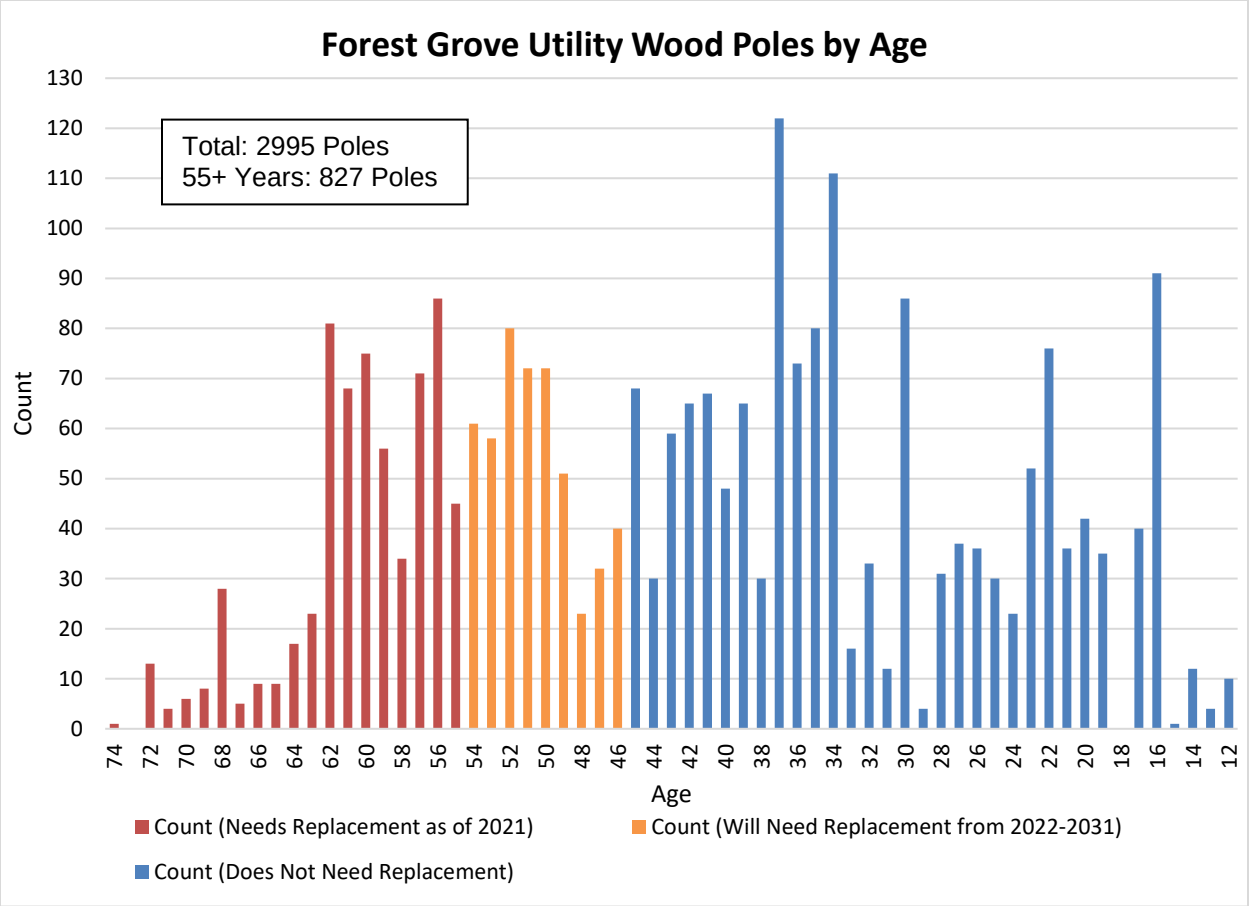

Figure 7-1. Number of utility wood poles by age.

All the red-colored bars represent the poles needing replacement as of 2022. All the blue-colored bars represent the poles under 55 years old.

8 12.5KV UNDERGROUND CABLE INVENTORY REVIEW AND REPLACEMENT SCHEDULE

The City of Forest Grove has approximately 414,640' of underground 12.5 kV primary cable in use as part of the system serving Forest Grove residents. This system includes three different cable types and three different installation methods; both have changed over the years based on technology advancements.
The three types of cable and installation methods include:

- Direct-buried non-jacketed XLP concentric 15 kV aluminum cable
- Non-jacketed XLP concentric 15 kV aluminum cable installed in conduit
- Jacketed EPR concentric 15 kV aluminum cable installed in conduit

The City of Forest Grove (and most other utilities) has experienced multiple failures of the direct-buried non-jacketed XLP concentric cables. As part of the City's resiliency and reliability plan, these cables are being replaced as workload allows. At this time, approximately 11% (45,600') of the underground cable system in 55 locations remain to be replaced. The City has not experienced an abnormal cable failure rate regarding the other two types of cable installed in conduit on its system.

According to the City of Forest Grove, replacing each span (approximately 348 ft) of cable requires approximately 160 man-hours. At the current rate of $130/hr., this will cost $3,010,000 to replace the remaining 131 spans of cable. Below is a 10-year replacement schedule for the spans of cable needing replacement.

Table 8-1. 10-Year Underground 15 kV Cable Replacement Schedule.

Year	Description	Cost
2022	14 Spans of Cable	$321,650
2023	13 Spans of Cable	$298,675
2024	13 Spans of Cable	$298,675
2025	13 Spans of Cable	$298,675
2026	13 Spans of Cable	$298,675
2027	13 Spans of Cable	$298,675
2028	13 Spans of Cable	$298,675
2029	13 Spans of Cable	$298,675
2030	13 Spans of Cable	$298,675
2031	13 Spans of Cable	$298,675
Estimated Construction Cost (Rounded)		**$3,010,000**

Spans of cable are separated in groups of 14 and 13 in order to maintain the same cost per year. The cost breakdown in terms of materials, installation, and equipment are located below in Table 8-2.

Table 8-2. Cost estimate table for underground cabling needing replacement.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
Spans of Cable	131	EA	$1,600	$209,600	$20,800	$2,724,800	$575	$75,325	$3,009,725
Estimated Construction Cost (Rounded)									**$3,010,000**

9 ELECTRICAL METER SYSTEM REPLACEMENT SCHEDULE AND FUTURE SYSTEM ADVISORY

Metering data provided by the City of Forest Grove indicates that a ten-thousand-meter automatic reader system (AMR) using field collection system (FCS) from Itron is used for the 10,650 meters. Forest Grove uses a mobile data collector that reads their residential and meters without demand in four read dates spread out monthly. Additionally, there are 190 meters that do not have radio reads available; thus, these meters are read manually. Because these meters utilize one-way communication via radio, meter reading is done by visiting each meter. This is a common metering system; however, upgrading to a two-way advanced metering infrastructure (AMI) metering system would benefit both the customer and the utility in a variety of ways. Below is a list of some of the key benefits:

- Remote meter reading by the utility, saving on the cost of driving out to each meter
- Irregularity or inefficiency detection in the distribution system
- Real-time load data accessibility by the customer
- Reduced response time to power loss, leading to a higher quality of service for the customer
- Pre-paid metering, allowing the customer to choose how much to pay in advance and preventing a large running balance for customers who cannot pay on time
- Remote disconnect, allowing the utility to easily disconnect power (valuable for temporary customers)
- Read on demand for start/stop service

Recommendations regarding metering will be provided by the City of Forest Grove Light & Power. Below is a graph depicting the number of meters by age.

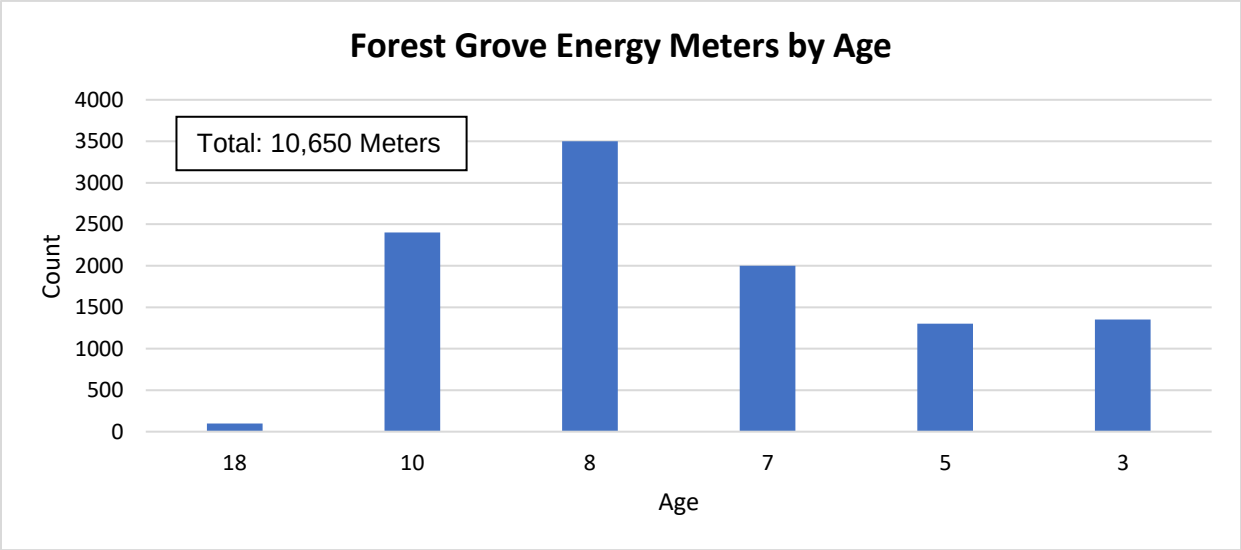

Figure 9-1. Number of meters by age.

10 SYSTEM SITUATIONAL AWARENESS ADVISORY

The City of Forest Grove utilizes SEL-3530 Real-Time Automation Controller (RTAC) at each substation and they are interconnected through fiber optic cabling for SCADA monitoring. This system is used to monitor real-time load conditions of substations and feeder circuits as well as overall system voltage regulation. In addition, it supervises over 80 critical alarm functions that impact distribution reliability and outages. The SCADA system is set to instantly notify management in an effort to mobilize personnel to the field.

The current arrangement has proven useful in scheduled outage coordination as well as non-scheduled system emergencies. The RTAC has the capability for remote control of field equipment, though it not being utilized at this time. Future capabilities include remote control and integration of field equipment to monitor line loads and auto-restore circuits interrupted by faulted equipment.

Elcon recommends the City upgrade its SCADA system with the SEL-3555 RTAC to facilitate future expansion in terms of functionality and security. The City of Forest Grove indicates that the SEL-3530 RTAC is used at all three substations and Light & Power Operations. This model is ideal for small to medium installations and applications integrating data for up to 60 devices. The SEL-3555 RTAC however can integrate up to 256 devices and support up to 100,000 data points. The SEL-3555 also features multicore processing at 2.0 GHz and configurable RAM options capable of running multiple applications simultaneously. There is also an optional integrated web HMI with a local display port, eliminating the need for an additional computer.

In addition, the same setup software – AcSelerator Quickset RTAC SEL-5033 Software is used to configure the SEL-3555 RTAC. To accommodate for future expansion efforts, the more powerful SEL-3555 should replace the SEL-3530.

Table 10-1. Comparison table of Real-Time Automation Controllers (RTAC).

	SEL-3530 RTAC 1U/3U	**SEL-3555 RTAC**
Unit Price	$4,870 USD	$7,910 USD
Processor	533 MHz	2.0 GHz Xeon Quad-core
RAM	1 GB	8 to 16 GB
Storage	2 GB	30 to 480 GB
Operation Temperature Range	-40C to +85C	-40C to +75C
Graphical Web-Based HMI	Viewing and control via web browser	Viewing and control via web browser; integrated video; 1 DisplayPort; 1 DVI/VGA port; 2 DVI-D port
Power Supply	Single; 120/240 Vac, 125/250 Vdc; 48/125 Vdc; 120 Vac; or 24/48 Vdc	Redundant: SEL-9331 Power Supply with 125/250 Vdc or 120/240 Vac; LV 48 Vdc

Appendix A FOREST GROVE SITE MAP

Site Map

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R i n g s : 3 , 5a, d1ii0 m i l e r

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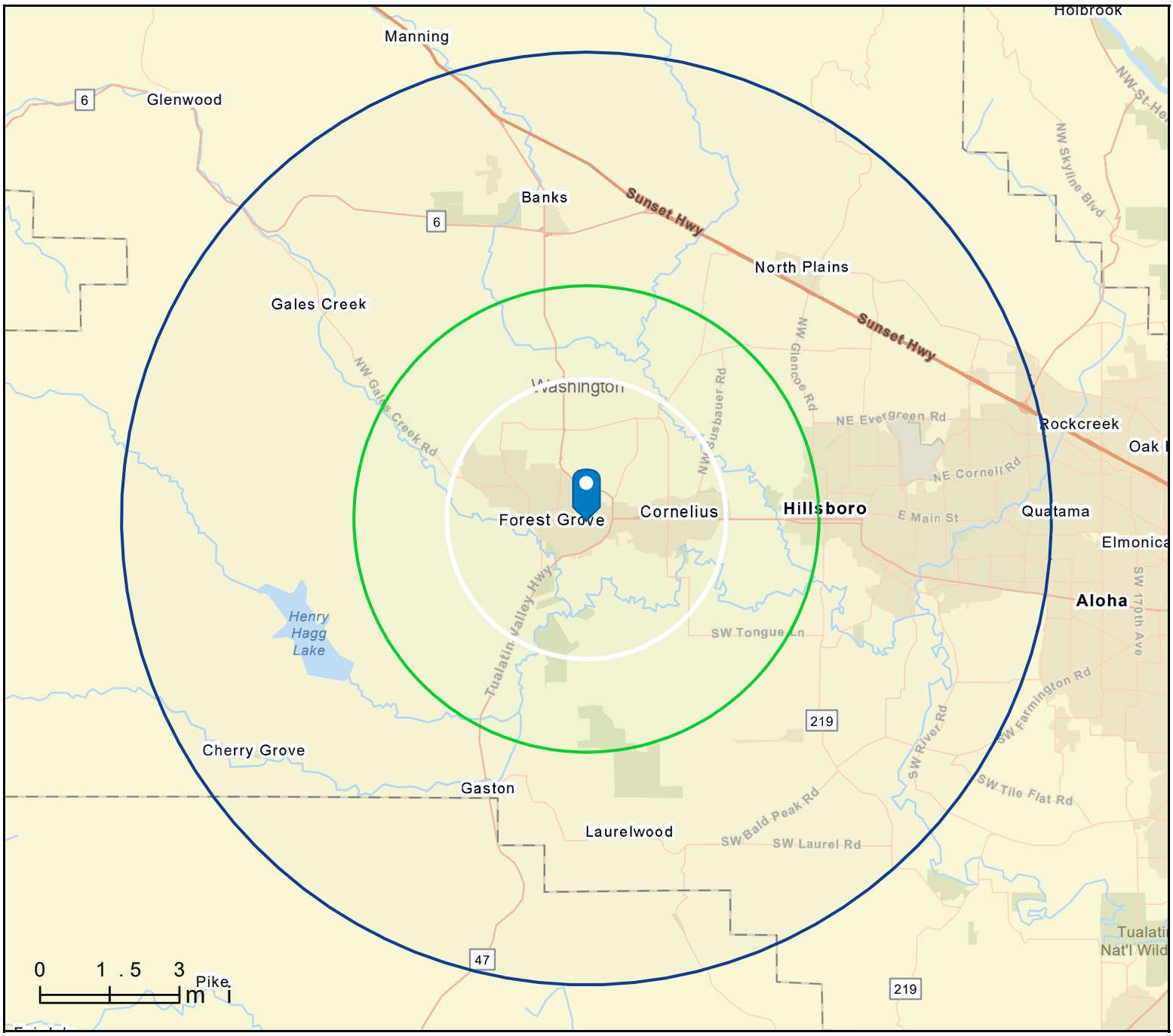
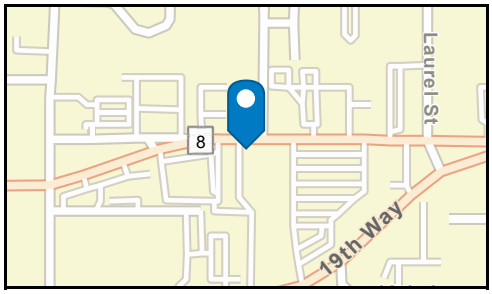
L a t i t u d e : 4 5
L o n g i t u d e : - 1





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Appendix B DEMOGRAPHIC AND INCOME PROFILE

Demographic and Income Profile

2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 3 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

Summary	Census 2010	2020	2025
Population	34,390	40,603	43,732
Households	11,283	13,173	14,181
Families	7,930	9,127	9,781
Average Household Size	2.94	2.98	2.99
Owner Occupied Housing Units	7,057	8,325	8,992
Renter Occupied Housing Units	4,226	4,849	5,189
Median Age	32.5	33.9	34.9

Trends: 2020-2025 Annual Rate	Area	State	National
Population	1.50%	1.08%	0.72%
Households	1.49%	1.08%	0.72%
Families	1.39%	0.97%	0.64%
Owner HHs	1.55%	1.01%	0.72%
Median Household Income	1.48%	2.07%	1.60%

	2020		2025	
Households by Income	Number	Percent	Number	Percent
<$15,000	984	7.5%	891	6.3%
$15,000 - $24,999	1,088	8.3%	1,081	7.6%
$25,000 - $34,999	958	7.3%	945	6.7%
$35,000 - $49,999	2,162	16.4%	2,188	15.4%
$50,000 - $74,999	2,788	21.2%	2,950	20.8%
$75,000 - $99,999	1,664	12.6%	1,836	12.9%
$100,000 - $149,999	2,222	16.9%	2,657	18.7%
$150,000 - $199,999	830	6.3%	1,078	7.6%
$200,000+	477	3.6%	556	3.9%
Median Household Income	$59,932		$64,505	
Average Household Income	$78,586		$86,330	
Per Capita Income	$25,764		$28,283	

	Census 2010		2020		2025	
Population by Age	Number	Percent	Number	Percent	Number	Percent
0 - 4	2,566	7.5%	2,877	7.1%	3,081	7.0%
5 - 9	2,779	8.1%	2,825	7.0%	3,047	7.0%
10 - 14	2,688	7.8%	2,746	6.8%	3,030	6.9%
15 - 19	3,009	8.7%	3,176	7.8%	3,182	7.3%
20 - 24	2,728	7.9%	3,111	7.7%	3,109	7.1%
25 - 34	4,566	13.3%	6,202	15.3%	6,516	14.9%
35 - 44	4,652	13.5%	4,968	12.2%	5,713	13.1%
45 - 54	4,411	12.8%	4,895	12.1%	4,980	11.4%
55 - 64	3,286	9.6%	4,436	10.9%	4,656	10.6%
65 - 74	1,808	5.3%	3,122	7.7%	3,655	8.4%
75 - 84	1,142	3.3%	1,450	3.6%	1,914	4.4%
85+	756	2.2%	795	2.0%	851	1.9%

	Census 2010		2020		2025	
Race and Ethnicity	Number	Percent	Number	Percent	Number	Percent
White Alone	25,695	74.7%	28,855	71.1%	30,146	68.9%
Black Alone	307	0.9%	440	1.1%	535	1.2%
American Indian Alone	389	1.1%	464	1.1%	514	1.2%
Asian Alone	797	2.3%	1,339	3.3%	1,670	3.8%
Pacific Islander Alone	73	0.2%	99	0.2%	116	0.3%
Some Other Race Alone	5,830	17.0%	7,558	18.6%	8,574	19.6%
Two or More Races	1,299	3.8%	1,848	4.6%	2,177	5.0%
Hispanic Origin (Any Race)	10,797	31.4%	13,929	34.3%	15,896	36.3%

Data Note: Income is expressed in current dollars.

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

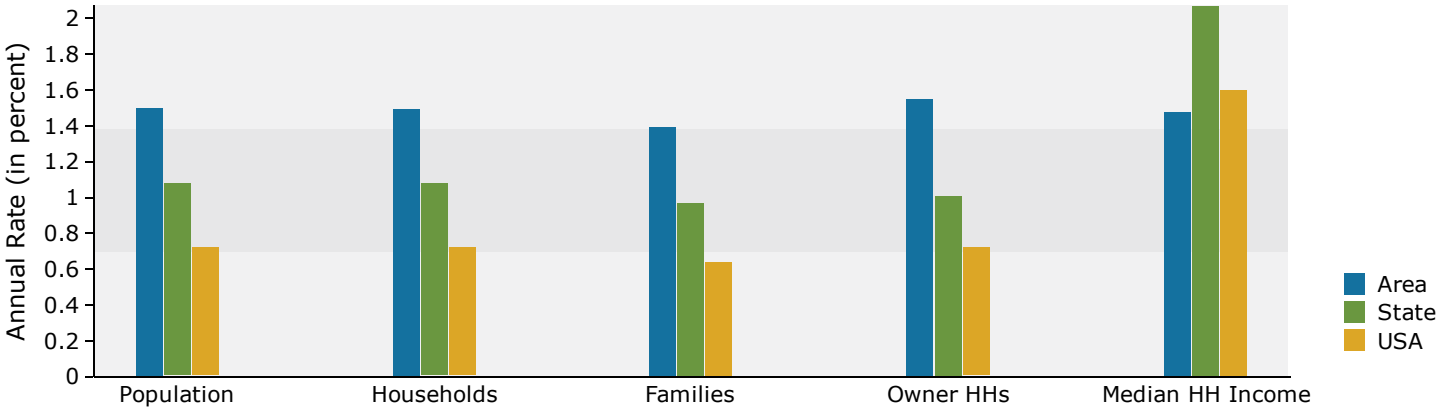
March 11, 2021

Demographic and Income Profile

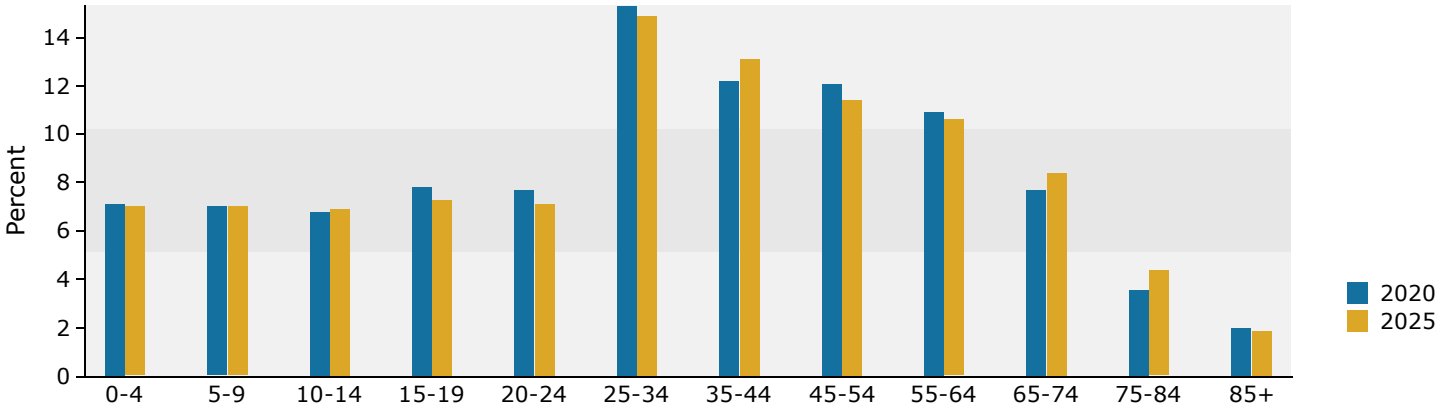
2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 3 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

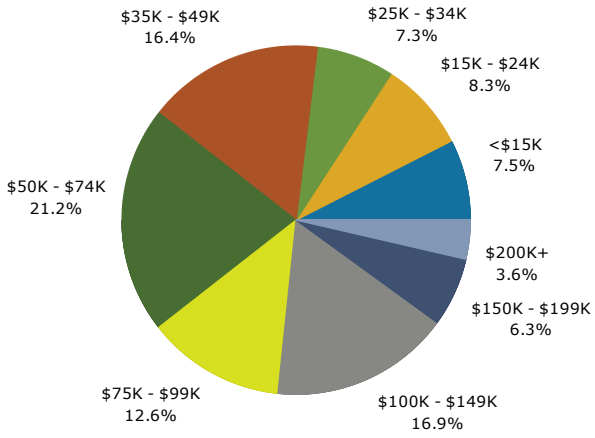
Trends 2020-2025



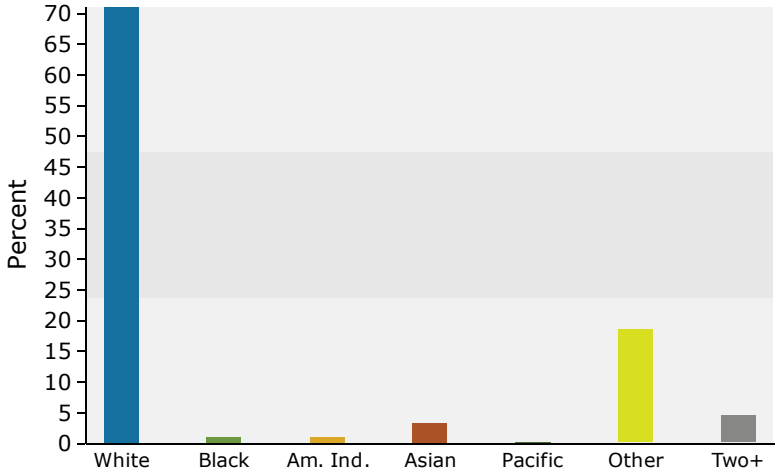
Population by Age



2020 Household Income



2020 Population by Race



2020 Percent Hispanic Origin:34.3%

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

March 11, 2021

Demographic and Income Profile

2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 5 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

Summary	Census 2010	2020	2025
Population	42,792	49,561	53,066
Households	13,970	16,005	17,130
Families	10,013	11,305	12,045
Average Household Size	2.95	2.99	3.00
Owner Occupied Housing Units	9,062	10,413	11,157
Renter Occupied Housing Units	4,908	5,592	5,974
Median Age	33.3	34.7	35.6

Trends: 2020-2025 Annual Rate	Area	State	National
Population	1.38%	1.08%	0.72%
Households	1.37%	1.08%	0.72%
Families	1.28%	0.97%	0.64%
Owner HHs	1.39%	1.01%	0.72%
Median Household Income	1.69%	2.07%	1.60%

	2020		2025	
Households by Income	Number	Percent	Number	Percent
<$15,000	1,162	7.3%	1,041	6.1%
$15,000 - $24,999	1,248	7.8%	1,221	7.1%
$25,000 - $34,999	1,136	7.1%	1,111	6.5%
$35,000 - $49,999	2,453	15.3%	2,457	14.3%
$50,000 - $74,999	3,274	20.5%	3,415	19.9%
$75,000 - $99,999	2,022	12.6%	2,205	12.9%
$100,000 - $149,999	2,900	18.1%	3,436	20.1%
$150,000 - $199,999	1,067	6.7%	1,383	8.1%
$200,000+	741	4.6%	860	5.0%
Median Household Income	$62,833		$68,321	
Average Household Income	$82,987		$91,275	
Per Capita Income	$27,083		$29,762	

	Census 2010		2020		2025	
Population by Age	Number	Percent	Number	Percent	Number	Percent
0 - 4	3,091	7.2%	3,406	6.9%	3,624	6.8%
5 - 9	3,377	7.9%	3,369	6.8%	3,610	6.8%
10 - 14	3,324	7.8%	3,291	6.6%	3,608	6.8%
15 - 19	3,627	8.5%	3,724	7.5%	3,714	7.0%
20 - 24	3,202	7.5%	3,685	7.4%	3,637	6.9%
25 - 34	5,776	13.5%	7,534	15.2%	7,867	14.8%
35 - 44	5,863	13.7%	6,210	12.5%	7,044	13.3%
45 - 54	5,701	13.3%	6,064	12.2%	6,173	11.6%
55 - 64	4,311	10.1%	5,619	11.3%	5,749	10.8%
65 - 74	2,302	5.4%	3,980	8.0%	4,680	8.8%
75 - 84	1,361	3.2%	1,782	3.6%	2,392	4.5%
85+	857	2.0%	896	1.8%	968	1.8%

	Census 2010		2020		2025	
Race and Ethnicity	Number	Percent	Number	Percent	Number	Percent
White Alone	32,413	75.7%	35,660	72.0%	37,029	69.8%
Black Alone	408	1.0%	577	1.2%	698	1.3%
American Indian Alone	470	1.1%	551	1.1%	606	1.1%
Asian Alone	1,043	2.4%	1,700	3.4%	2,103	4.0%
Pacific Islander Alone	88	0.2%	115	0.2%	133	0.3%
Some Other Race Alone	6,726	15.7%	8,664	17.5%	9,808	18.5%
Two or More Races	1,644	3.8%	2,295	4.6%	2,690	5.1%
Hispanic Origin (Any Race)	12,552	29.3%	16,083	32.5%	18,312	34.5%

Data Note: Income is expressed in current dollars.

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

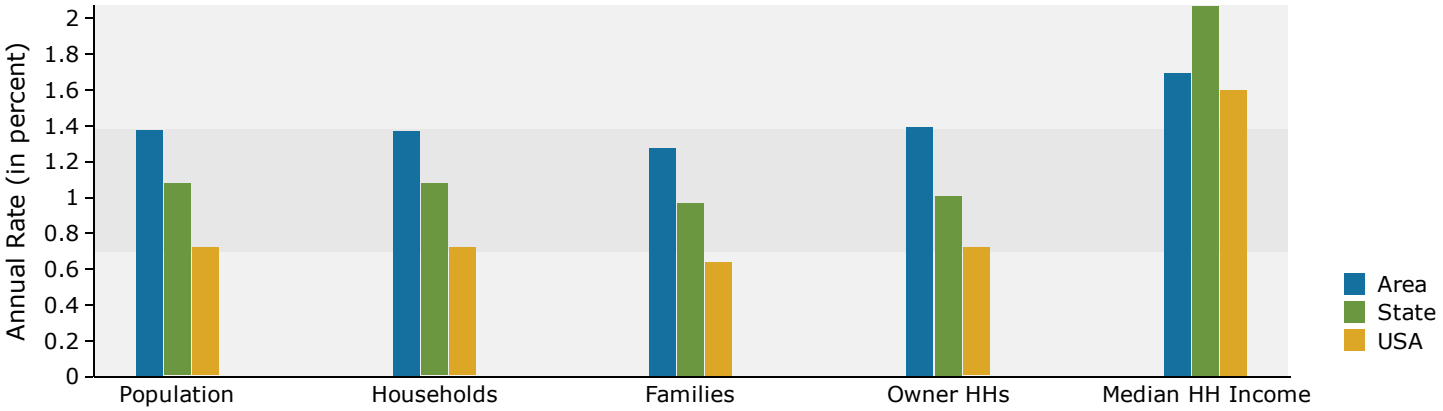
March 11, 2021

Demographic and Income Profile

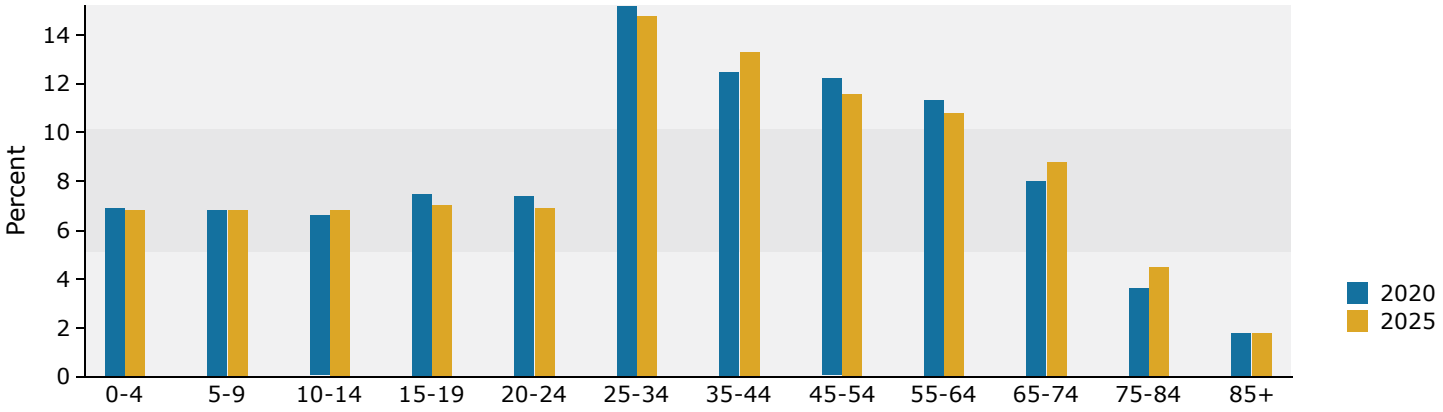
2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 5 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

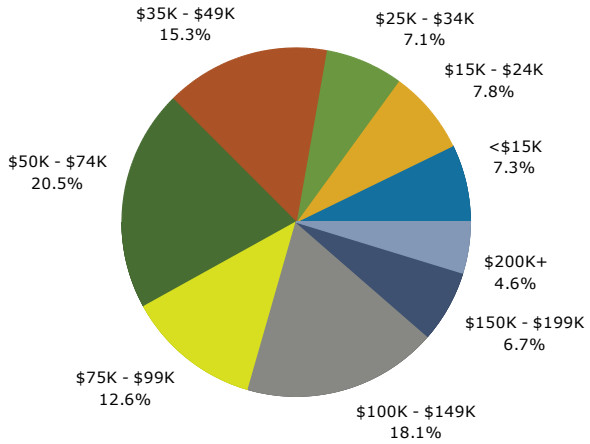
Trends 2020-2025



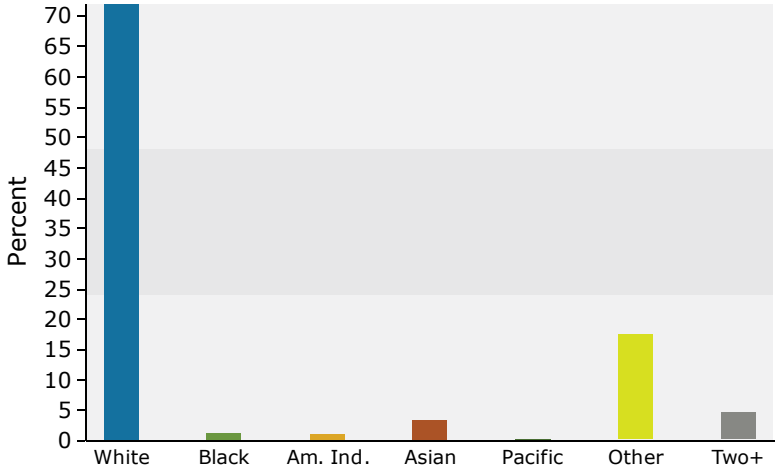
Population by Age



2020 Household Income



2020 Population by Race



2020 Percent Hispanic Origin:32.5%

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

March 11, 2021

Demographic and Income Profile

2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 10 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

Summary	Census 2010	2020	2025
Population	143,615	164,963	176,578
Households	49,646	57,030	61,162
Families	35,692	40,172	42,784
Average Household Size	2.84	2.84	2.84
Owner Occupied Housing Units	32,570	36,929	39,132
Renter Occupied Housing Units	17,076	20,101	22,030
Median Age	33.7	35.4	36.0

Trends: 2020-2025 Annual Rate	Area	State	National
Population	1.37%	1.08%	0.72%
Households	1.41%	1.08%	0.72%
Families	1.27%	0.97%	0.64%
Owner HHs	1.17%	1.01%	0.72%
Median Household Income	2.00%	2.07%	1.60%

	2020		2025	
Households by Income	Number	Percent	Number	Percent
<$15,000	2,903	5.1%	2,528	4.1%
$15,000 - $24,999	3,229	5.7%	2,989	4.9%
$25,000 - $34,999	3,353	5.9%	3,171	5.2%
$35,000 - $49,999	6,537	11.5%	6,266	10.2%
$50,000 - $74,999	9,909	17.4%	9,901	16.2%
$75,000 - $99,999	8,195	14.4%	8,676	14.2%
$100,000 - $149,999	12,882	22.6%	15,054	24.6%
$150,000 - $199,999	5,791	10.2%	7,454	12.2%
$200,000+	4,232	7.4%	5,125	8.4%
Median Household Income	$81,377		$89,868	
Average Household Income	$100,185		$111,342	
Per Capita Income	$34,725		$38,663	

	Census 2010		2020		2025	
Population by Age	Number	Percent	Number	Percent	Number	Percent
0 - 4	11,096	7.7%	11,589	7.0%	12,301	7.0%
5 - 9	11,027	7.7%	11,480	7.0%	11,920	6.8%
10 - 14	10,823	7.5%	11,319	6.9%	11,958	6.8%
15 - 19	10,327	7.2%	10,930	6.6%	11,234	6.4%
20 - 24	9,050	6.3%	10,890	6.6%	10,981	6.2%
25 - 34	22,386	15.6%	25,273	15.3%	27,360	15.5%
35 - 44	21,549	15.0%	23,410	14.2%	24,928	14.1%
45 - 54	19,234	13.4%	20,549	12.5%	21,425	12.1%
55 - 64	14,783	10.3%	18,712	11.3%	19,021	10.8%
65 - 74	7,455	5.2%	13,145	8.0%	15,298	8.7%
75 - 84	3,922	2.7%	5,417	3.3%	7,722	4.4%
85+	1,963	1.4%	2,249	1.4%	2,430	1.4%

	Census 2010		2020		2025	
Race and Ethnicity	Number	Percent	Number	Percent	Number	Percent
White Alone	109,637	76.3%	118,487	71.8%	122,310	69.3%
Black Alone	1,950	1.4%	2,885	1.7%	3,552	2.0%
American Indian Alone	1,470	1.0%	1,682	1.0%	1,834	1.0%
Asian Alone	8,405	5.9%	13,428	8.1%	16,545	9.4%
Pacific Islander Alone	517	0.4%	637	0.4%	722	0.4%
Some Other Race Alone	15,802	11.0%	19,876	12.0%	22,328	12.6%
Two or More Races	5,835	4.1%	7,968	4.8%	9,288	5.3%
Hispanic Origin (Any Race)	33,350	23.2%	41,651	25.2%	47,081	26.7%

Data Note: Income is expressed in current dollars.

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

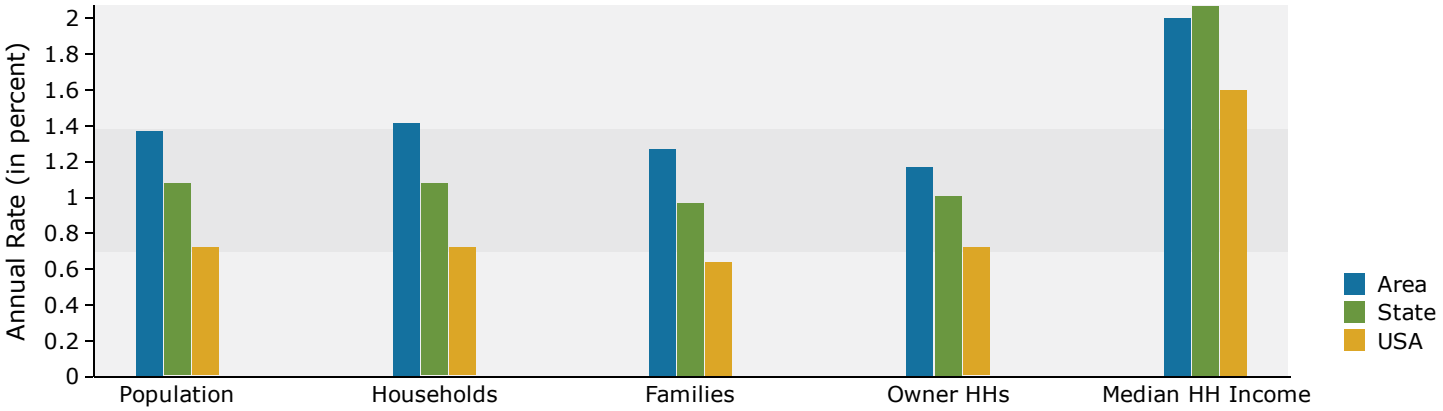
March 11, 2021

Demographic and Income Profile

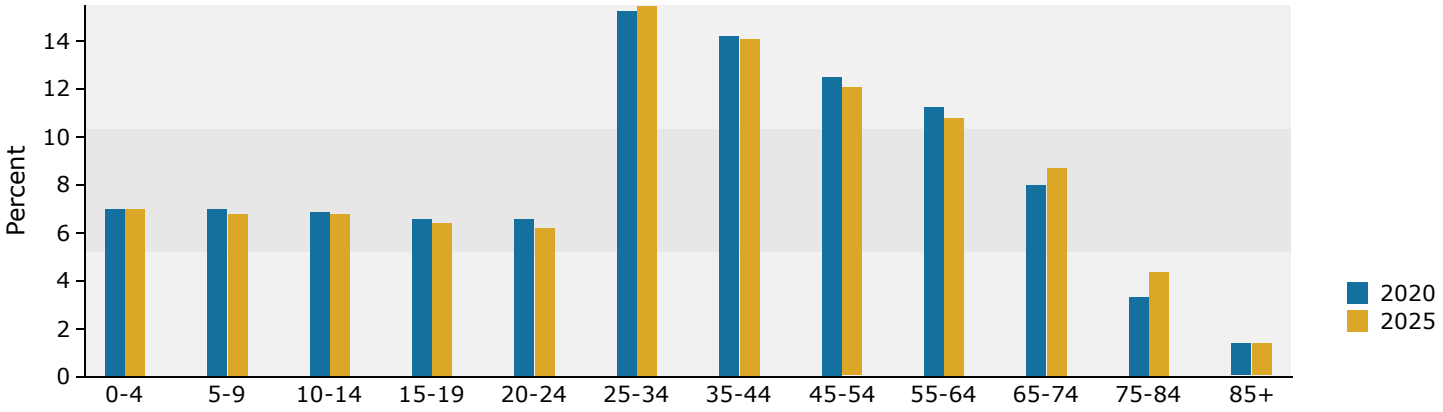
2836 Pacific Ave, Forest Grove, Oregon, 97116
Ring: 10 mile radius

Prepared by Esri
Latitude: 45.52011
Longitude: -123.09585

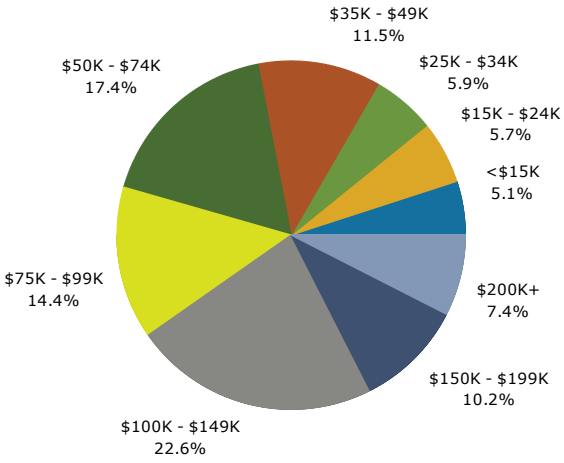
Trends 2020-2025



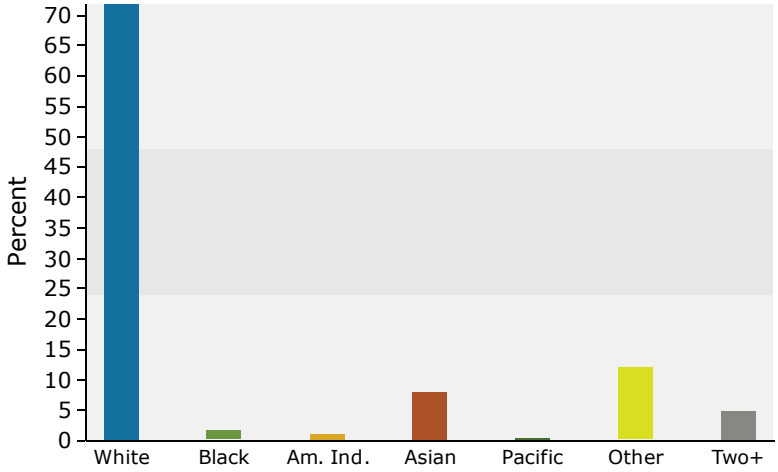
Population by Age



2020 Household Income



2020 Population by Race



2020 Percent Hispanic Origin:25.2%

Source: U.S. Census Bureau, Census 2010 Summary File 1. Esri forecasts for 2020 and 2025.

March 11, 2021

Appendix C DISTRIBUTION TRANSFORMER COST DATA

Below are cost estimate tables for distribution transformers needing replacement as of 2021 through 2031. These tables detail the cost of the different configurations of distribution transformers and the associated materials, labor, and equipment cost. A budgetary quote from the City of Forest Grove was used, along with the 2021 Electrical Costs with RSMeans data.

Table C-1. Cost estimate table for distribution transformers needing replacement as of 2021.

			Materials		Labor		Equipment		
Description	Qty	Units	$/Unit	Total	$/Unit	Total	$/Unit	Total	Total
5 kVA Pole, Single Phase, 120/240V	13	EA	$562	$7,311	$445	$5,785	$42	$546	$13,642
7 kVA Pole, Single Phase, 120/240V	3	EA	$593	$1,779	$445	$1,335	$42	$126	$3,240
10 kVA Pole, Single Phase, 120/240V	31	EA	$674	$20,903	$445	$13,795	$42	$1,302	$36,000
15 kVA Pole, Single Phase, 120/240V	23	EA	$738	$16,976	$445	$10,235	$42	$966	$28,177
25 kVA Pole, Single Phase, 120/240V	66	EA	$911	$60,113	$500	$33,000	$47	$3,102	$96,215
50 kVA Pole, Single Phase, 120/240V	156	EA	$2,046	$319,176	$810	$126,360	$76	$11,856	$457,392
75 kVA Pole, Single Phase, 120/240V	3	EA	$1,689	$5,066	$1,000	$3,000	$94	$282	$8,348
37.5 kVA Pole, Single Phase, 120/240V	47	EA	$1,044	$49,063	$695	$32,665	$66	$3,079	$84,807
25 kVA Subm, Single Phase, 120/240V	1	EA	$910	$910	$500	$500	$47	$47	$1,457
50 kVA Subm, Single Phase, 120/240V	1	EA	$2,046	$2,046	$810	$810	$76	$76	$2,932
100 kVA Pole, Single Phase, 120/240V	17	EA	$3,573	$60,741	$1,100	$18,700	$102	$1,734	$81,175
167 kVA Pole, Single Phase, 120/240V	3	EA	$3,571	$10,713	$1,575	$4,725	$239	$717	$16,155
150 kVA Pad, 3 Phase, 120/208V	1	EA	$6,416	$6,416	$1,950	$1,950	$294	$294	$8,660
300 kVA Pad, 3 Phase, 120/208V	1	EA	$8,839	$8,839	$2,825	$2,825	$425	$425	$12,089
750 kVA Pad, 3 Phase, 277/480V	1	EA	$15,239	$15,239	$3,350	$3,350	$505	$505	$19,094
100 kVA Pole, Single Phase, 277V	3	EA	$2,670	$8,010	$1,100	$3,300	$102	$306	$11,616
Estimated Construction Cost (Rounded)									**$865,000**

Table C-2. Cost estimate table for distribution transformers needing replacement as of 2022.

			Materials		Labor		Equipment		
Description	Qty	Units	$/Unit	Total	$/Unit	Total	$/Unit	Total	Total
10 kVA Pole, Single Phase, 120/240V	8	EA	$674	$5,394	$445	$3,560	$42	$336	$9,290
25 kVA Pole, Single Phase, 120/240V	24	EA	$911	$21,859	$500	$12,000	$47	$1,128	$34,987
50 kVA Pole, Single Phase, 120/240V	20	EA	$2,046	$40,920	$810	$16,200	$76	$1,520	$58,640
25 kVA Subm, Single Phase, 120/240V	1	EA	$910	$910	$500	$500	$47	$47	$1,457
50 kVA Subm, Single Phase, 120/240V	1	EA	$2,046	$2,046	$810	$810	$76	$76	$2,932
100 kVA Pole, Single Phase, 120/240V	3	EA	$3,573	$10,719	$1,100	$3,300	$102	$306	$14,325
100 kVA Pole, Single Phase, 277V	2	EA	$2,670	$5,340	$1,100	$2,200	$102	$204	$7,744
Estimated Construction Cost (Rounded)									**$130,000**

Table C-3. Cost estimate table for distribution transformers needing replacement as of 2023.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	7	EA	$911	$6,376	$500	$3,500	$47	$329	$10,205
50 kVA Pole, Single Phase, 120/240V	21	EA	$2,046	$42,966	$810	$17,010	$76	$1,596	$61,572
100 kVA Pole, Single Phase, 120/240V	2	EA	$3,573	$7,146	$1,100	$2,200	$102	$204	$9,550
Estimated Construction Cost (Rounded)									**$82,000**

Table C-4. Cost estimate table for distribution transformers needing replacement as of 2024.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	27	EA	$911	$24,592	$500	$13,500	$47	$1,269	$39,361
50 kVA Pole, Single Phase, 120/240V	8	EA	$2,046	$16,368	$810	$6,480	$76	$608	$23,456
100 kVA Pole, Single Phase, 120/240V	2	EA	$3,573	$7,146	$1,100	$2,200	$102	$204	$9,550
167 kVA Pole, Single Phase, 120/240V	2	EA	$3,571	$7,142	$1,575	$3,150	$239	$478	$10,770
150 kVA Pad, 3 Phase, 120/208V	1	EA	$6,416	$6,416	$1,950	$1,950	$294	$294	$8,660
300 kVA Pad, 3 Phase, 120/208V	1	EA	$8,839	$8,839	$2,825	$2,825	$425	$425	$12,089
500 kVA Pad, 3 Phase, 120/208V	2	EA	$11,261	$22,521	$3,175	$6,350	$480	$960	$29,831
1000 kVA Pad, 3 Phase, 277/480V	1	EA	$18,676	$18,676	$3,975	$3,975	$595	$595	$23,246
Estimated Construction Cost (Rounded)									**$157,000**

Table C-5. Cost estimate table for distribution transformers needing replacement as of 2025.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	14	EA	$911	$12,751	$500	$7,000	$47	$658	$20,409
50 kVA Pole, Single Phase, 120/240V	2	EA	$2,046	$4,092	$810	$1,620	$76	$152	$5,864
250 kVA Pole, Single Phase, 120/240V	1	EA	$5,000	$5,000	$2,300	$2,300	$345	$345	$7,645
10 kVA Pad, Single Phase, 120/240V	3	EA	$1,089	$3,267	$400	$1,200	$38	$114	$4,581
500 kVA Pad, 3 Phase, 277/480V	1	EA	$11,802	$11,802	$3,175	$3,175	$480	$480	$15,457
Estimated Construction Cost (Rounded)									**$54,000**

Table C-6. Cost estimate table for distribution transformers needing replacement as of 2026.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	12	EA	$911	$10,930	$500	$6,000	$47	$564	$17,494
50 kVA Pole, Single Phase, 120/240V	7	EA	$2,046	$14,322	$810	$5,670	$76	$532	$20,524
75 kVA Pole, Single Phase, 120/240V	2	EA	$1,689	$3,377	$1,000	$2,000	$94	$188	$5,565
100 kVA Pole, Single Phase, 120/240V	4	EA	$3,573	$14,292	$1,100	$4,400	$102	$408	$19,100
25 kVA Pad, Single Phase, 120/240V	2	EA	$1,393	$2,785	$500	$1,000	$47	$94	$3,879
112 kVA Pad, 3 Phase, 120/208V	1	EA	$5,803	$5,803	$1,950	$1,950	$294	$294	$8,047
750 kVA Pad, 3 Phase, 277/480V	1	EA	$15,239	$15,239	$3,350	$3,350	$505	$505	$19,094
Estimated Construction Cost (Rounded)									**$94,000**

Table C-7. Cost estimate table for distribution transformers needing replacement as of 2027.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	12	EA	$911	$10,930	$500	$6,000	$47	$564	$17,494
50 kVA Pole, Single Phase, 120/240V	16	EA	$2,046	$32,736	$810	$12,960	$76	$1,216	$46,912
25 kVA Subm, Single Phase, 120/240V	1	EA	$910	$910	$500	$500	$47	$47	$1,457
50 kVA Subm, Single Phase, 120/240V	1	EA	$2,046	$2,046	$810	$810	$76	$76	$2,932
10 kVA Pad, Single Phase, 120/240V	1	EA	$1,089	$1,089	$445	$445	$42	$42	$1,576
150 kVA Pad, 3 Phase, 120/208V	2	EA	$6,416	$12,833	$1,950	$3,900	$294	$588	$17,321
Estimated Construction Cost (Rounded)									**$88,000**

Table C-8. Cost estimate table for distribution transformers needing replacement as of 2028.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	16	EA	$911	$14,573	$500	$8,000	$47	$752	$23,325
100 kVA Pole, Single Phase, 120/240V	3	EA	$3,573	$10,719	$1,100	$3,300	$102	$306	$14,325
250 kVA Pole, Single Phase, 120/240V	3	EA	$5,000	$15,000	$2,300	$6,900	$345	$1,035	$22,935
25 kVA Pad, Single Phase, 120/240V	9	EA	$1,393	$12,533	$500	$4,500	$47	$423	$17,456
50 kVA Pad, Single Phase, 120/240V	19	EA	$2,046	$38,874	$810	$15,390	$76	$1,444	$55,708
75 kVA Pad, Single Phase, 120/240V	5	EA	$2,451	$12,254	$1,000	$5,000	$94	$470	$17,724
100 kVA Pad, Single Phase, 120/240V	4	EA	$3,573	$14,291	$1,100	$4,400	$102	$408	$19,099
300 kVA Pad, 3 Phase, 120/208V	2	EA	$8,839	$17,677	$2,825	$5,650	$425	$850	$24,177
500 kVA Pad, 3 Phase, 120/208V	2	EA	$11,261	$22,521	$3,175	$6,350	$480	$960	$29,831
150 kVA Pad, 3 Phase, 277/480V	2	EA	$6,992	$13,983	$1,950	$3,900	$294	$588	$18,471
750 kVA Pad, 3 Phase, 277/480V	1	EA	$15,239	$15,239	$3,350	$3,350	$505	$505	$19,094
Estimated Construction Cost (Rounded)									**$263,000**

Table C-9. Cost estimate table for distribution transformers needing replacement as of 2029.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
25 kVA Pole, Single Phase, 120/240V	8	EA	$911	$7,286	$500	$4,000	$47	$376	$11,662
50 kVA Pole, Single Phase, 120/240V	1	EA	$2,046	$2,046	$810	$810	$76	$76	$2,932
50 kVA Subm, Single Phase, 120/240V	8	EA	$2,046	$16,368	$810	$6,480	$76	$608	$23,456
100 kVA Subm, Single Phase, 120/240V	2	EA	$3,573	$7,146	$1,100	$2,200	$102	$204	$9,550
167 kVA Subm, Single Phase, 120/240V	2	EA	$3,573	$7,146	$1,100	$2,200	$102	$204	$9,550
25 kVA Pad, Single Phase, 120/240V	4	EA	$1,393	$5,570	$500	$2,000	$47	$188	$7,758
50 kVA Pad, Single Phase, 120/240V	50	EA	$2,046	$102,300	$810	$40,500	$76	$3,800	$146,600
75 kVA Pad, Single Phase, 120/240V	12	EA	$2,451	$29,410	$1,000	$12,000	$94	$1,128	$42,538
100 kVA Pad, Single Phase, 120/240V	3	EA	$3,573	$10,718	$1,100	$3,300	$102	$306	$14,324
75 kVA Pad, 3 Phase, 120/208V	1	EA	$5,205	$5,205	$1,275	$1,275	$200	$200	$6,680
112 kVA Pad, 3 Phase, 120/208V	1	EA	$5,803	$5,803	$1,950	$1,950	$294	$294	$8,047
300 kVA Pad, 3 Phase, 120/208V	2	EA	$8,839	$17,677	$2,825	$5,650	$425	$850	$24,177
75 kVA Pad, 3 Phase, 277/480V	1	EA	$5,961	$5,961	$1,000	$1,000	$94	$94	$7,055
150 kVA Pad, 3 Phase, 277/480V	2	EA	$6,992	$13,983	$1,950	$3,900	$294	$588	$18,471
300 kVA Pad, 3 Phase, 277/480V	1	EA	$9,053	$9,053	$2,825	$2,825	$425	$425	$12,303
500 kVA Pad, 3 Phase, 277/480V	1	EA	$11,802	$11,802	$3,175	$3,175	$480	$480	$15,457
100 kVA Pole, Single Phase, 277V	3	EA	$2,670	$8,010	$1,100	$3,300	$102	$306	$11,616
167 kVA Pole, Single Phase, 277V	1	EA	3570.6	$3,571	1400	$1,400	131	$131	$5,102
Estimated Construction Cost (Rounded)									**$373,000**

Table C-10. Cost estimate table for distribution transformers needing replacement as of 2030.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
10 kVA Pole, Single Phase, 120/240V	5	EA	$674	$3,372	$445	$2,225	$42	$210	$5,807
15 kVA Pole, Single Phase, 120/240V	6	EA	$738	$4,429	$445	$2,670	$42	$252	$7,351
25 kVA Pole, Single Phase, 120/240V	9	EA	$911	$8,197	$500	$4,500	$47	$423	$13,120
50 kVA Subm, Single Phase, 120/240V	6	EA	$2,046	$12,276	$810	$4,860	$76	$456	$17,592
15 kVA Pad, Single Phase, 120/240V	2	EA	$738	$1,476	$445	$890	$42	$84	$2,450
75 kVA Pad, Single Phase, 120/240V	6	EA	$2,451	$14,705	$1,000	$6,000	$94	$564	$21,269
Estimated Construction Cost (Rounded)									**$68,000**

Table C-11. Cost estimate table for distribution transformers needing replacement as of 2031.

Description	Qty	Units	Materials		Labor		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
10 kVA Pole, Single Phase, 120/240V	6	EA	$674	$4,046	$445	$2,670	$42	$252	$6,968
25 kVA Pole, Single Phase, 120/240V	17	EA	$911	$15,484	$500	$8,500	$47	$799	$24,783
250 kVA Pole, Single Phase, 120/240V	2	EA	$5,000	$10,000	$2,300	$4,600	$345	$690	$15,290
25 kVA Pad, Single Phase, 120/240V	9	EA	$1,393	$12,533	$500	$4,500	$47	$423	$17,456
150 kVA Pad, 3 Phase, 120/208V	1	EA	$6,416	$6,416	$1,950	$1,950	$294	$294	$8,660
500 kVA Pad, 3 Phase, 277/480V	1	EA	$11,802	$11,802	$3,175	$3,175	$480	$480	$15,457
1000 kVA Pad, 3 Phase, 277/480V	1	EA	$18,676	$18,676	$3,975	$3,975	$595	$595	$23,246
1500 kVA Pad, 3 Phase, 277/480V	1	EA	$22,113	$22,113	$5,525	$5,525	$830	$830	$28,468
100 kVA Pole, Single Phase, 277V	2	EA	$2,670	$5,340	$1,100	$2,200	$102	$204	$7,744
Estimated Construction Cost (Rounded)									**$149,000**

Appendix D POLE COST DATA

Below are cost estimate tables for poles needing replacement as of 2021 through 2031. These tables detail the cost of the different lengths of wooden poles and the associated materials, installation, and equipment cost.

Table D-1. Cost estimate table for poles needing replacement as of 2021.

			Materials		Installation		Equipment		
Description	Qty	Units	$/Unit	Total	$/Unit	Total	$/Unit	Total	Total
25' Wooden Pole	1	EA	$456	$456	$10,400	$10,400	$910	$910	$11,766
30' Wooden Pole	124	EA	$456	$56,544	$10,400	$1,289,600	$910	$112,840	$1,458,984
35' Wooden Pole	28	EA	$608	$17,024	$10,400	$291,200	$910	$25,480	$333,704
40' Wooden Pole	346	EA	$689	$238,394	$10,400	$3,598,400	$910	$314,860	$4,151,654
45' Wooden Pole	197	EA	$919	$181,043	$10,400	$2,048,800	$910	$179,270	$2,409,113
50' Wooden Pole	52	EA	$963	$50,076	$10,400	$540,800	$910	$47,320	$638,196
55' Wooden Pole	10	EA	$1,079	$10,790	$10,400	$104,000	$910	$9,100	$123,890
65' Wooden Pole	2	EA	$1,550	$3,100	$10,400	$20,800	$910	$1,820	$25,720
70' Wooden Pole	6	EA	$1,871	$11,226	$10,400	$62,400	$910	$5,460	$79,086
75' Wooden Pole	8	EA	$2,082	$16,656	$10,400	$83,200	$910	$7,280	$107,136
80' Wooden Pole	2	EA	$2,318	$4,636	$10,400	$20,800	$910	$1,820	$27,256
85' Wooden Pole	4	EA	$2,601	$10,404	$10,400	$41,600	$910	$3,640	$55,644
90' Wooden Pole	4	EA	$2,956	$11,824	$10,400	$41,600	$910	$3,640	$57,064
95' Wooden Pole	43	EA	$3,233	$139,019	$10,400	$447,200	$910	$39,130	$625,349
Estimated Construction Cost (Rounded)									**$10,105,000**

Table D-2. Cost estimate table for poles needing replacement for 2022.

			Materials		Installation		Equipment		
Description	Qty	Units	$/Unit	Total	$/Unit	Total	$/Unit	Total	Total
30' Wooden Pole	5	EA	$456	$2,280	$10,400	$52,000	$910	$4,550	$58,830
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	20	EA	$689	$13,780	$10,400	$208,000	$910	$18,200	$239,980
45' Wooden Pole	17	EA	$919	$15,623	$10,400	$176,800	$910	$15,470	$207,893
50' Wooden Pole	1	EA	$963	$963	$10,400	$10,400	$910	$910	$12,273
Estimated Construction Cost (Rounded)									**$531,000**

Table D-3. Cost estimate table for poles needing replacement for 2023.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	6	EA	$456	$2,736	$10,400	$62,400	$910	$5,460	$70,596
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	33	EA	$689	$22,737	$10,400	$343,200	$910	$30,030	$395,967
45' Wooden Pole	21	EA	$919	$19,299	$10,400	$218,400	$910	$19,110	$256,809
Estimated Construction Cost (Rounded)									**$736,000**

Table D-4. Cost estimate table for poles needing replacement for 2024.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	11	EA	$456	$5,016	$10,400	$114,400	$910	$10,010	$129,426
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	25	EA	$689	$17,225	$10,400	$260,000	$910	$22,750	$299,975
45' Wooden Pole	14	EA	$919	$12,866	$10,400	$145,600	$910	$12,740	$171,206
50' Wooden Pole	6	EA	$963	$5,778	$10,400	$62,400	$910	$5,460	$73,638
60' Wooden Pole	1	EA	$1,423	$1,423	$10,400	$10,400	$910	$910	$12,733
Estimated Construction Cost (Rounded)									**$699,000**

Table D-5. Cost estimate table for poles needing replacement for 2025.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	10	EA	$456	$4,560	$10,400	$104,000	$910	$9,100	$117,660
40' Wooden Pole	42	EA	$689	$28,938	$10,400	$436,800	$910	$38,220	$503,958
45' Wooden Pole	23	EA	$919	$21,137	$10,400	$239,200	$910	$20,930	$281,267
50' Wooden Pole	2	EA	$963	$1,926	$10,400	$20,800	$910	$1,820	$24,546
55' Wooden Pole	3	EA	$1,079	$3,237	$10,400	$31,200	$910	$2,730	$37,167
Estimated Construction Cost (Rounded)									**$965,000**

Table D-6. Cost estimate table for poles needing replacement for 2026.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	12	EA	$456	$5,472	$10,400	$124,800	$910	$10,920	$141,192
35' Wooden Pole	4	EA	$608	$2,432	$10,400	$41,600	$910	$3,640	$47,672
40' Wooden Pole	44	EA	$689	$30,316	$10,400	$457,600	$910	$40,040	$527,956
45' Wooden Pole	10	EA	$919	$9,190	$10,400	$104,000	$910	$9,100	$122,290
50' Wooden Pole	2	EA	$963	$1,926	$10,400	$20,800	$910	$1,820	$24,546
Estimated Construction Cost (Rounded)									**$864,000**

Table D-7. Cost estimate table for poles needing replacement for 2027.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	11	EA	$456	$5,016	$10,400	$114,400	$910	$10,010	$129,426
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	33	EA	$689	$22,737	$10,400	$343,200	$910	$30,030	$395,967
45' Wooden Pole	27	EA	$919	$24,813	$10,400	$280,800	$910	$24,570	$330,183
Estimated Construction Cost (Rounded)									**$868,000**

Table D-8. Cost estimate table for poles needing replacement for 2028.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	16	EA	$456	$7,296	$10,400	$166,400	$910	$14,560	$188,256
40' Wooden Pole	14	EA	$689	$9,646	$10,400	$145,600	$910	$12,740	$167,986
45' Wooden Pole	16	EA	$919	$14,704	$10,400	$166,400	$910	$14,560	$195,664
50' Wooden Pole	4	EA	$963	$3,852	$10,400	$41,600	$910	$3,640	$49,092
55' Wooden Pole	1	EA	$1,079	$1,079	$10,400	$10,400	$910	$910	$12,389
Estimated Construction Cost (Rounded)									**$614,000**

Table D-9. Cost estimate table for poles needing replacement for 2029.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	3	EA	$456	$1,368	$10,400	$31,200	$910	$2,730	$35,298
40' Wooden Pole	10	EA	$689	$6,890	$10,400	$104,000	$910	$9,100	$119,990
45' Wooden Pole	5	EA	$919	$4,595	$10,400	$52,000	$910	$4,550	$61,145
50' Wooden Pole	3	EA	$963	$2,889	$10,400	$31,200	$910	$2,730	$36,819
55' Wooden Pole	1	EA	$1,079	$1,079	$10,400	$10,400	$910	$910	$12,389
60' Wooden Pole	1	EA	$1,423	$1,423	$10,400	$10,400	$910	$910	$12,733
Estimated Construction Cost (Rounded)									**$279,000**

Table D-10. Cost estimate table for poles needing replacement for 2030.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	4	EA	$456	$1,824	$10,400	$41,600	$910	$3,640	$47,064
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	19	EA	$689	$13,091	$10,400	$197,600	$910	$17,290	$227,981
45' Wooden Pole	6	EA	$919	$5,514	$10,400	$62,400	$910	$5,460	$73,374
50' Wooden Pole	1	EA	$963	$963	$10,400	$10,400	$910	$910	$12,273
Estimated Construction Cost (Rounded)									**$373,000**

Table D-11. Cost estimate table for poles needing replacement for 2031.

Description	Qty	Units	Materials		Installation		Equipment		Total
			$/Unit	Total	$/Unit	Total	$/Unit	Total	
30' Wooden Pole	10	EA	$456	$4,560	$10,400	$104,000	$910	$9,100	$117,660
35' Wooden Pole	1	EA	$608	$608	$10,400	$10,400	$910	$910	$11,918
40' Wooden Pole	16	EA	$689	$11,024	$10,400	$166,400	$910	$14,560	$191,984
45' Wooden Pole	11	EA	$919	$10,109	$10,400	$114,400	$910	$10,010	$134,519
50' Wooden Pole	2	EA	$963	$1,926	$10,400	$20,800	$910	$1,820	$24,546
Estimated Construction Cost (Rounded)									**$481,000**

Appendix E 12.5KV BUS AMPACITY CALCULATIONS

In accordance with IEEE Std. 605, the ampacity of the bus conductor is determined by either the electrical system requirements or the ampacity of the connected equipment and limited by the conductor's maximum operating temperature. The current for a given conductor temperature rise is calculated as follows:

$$I = \sqrt{\frac{q_c + q_r + q_{cond} - q_s}{RF}} \qquad (1)$$

where

I	is the current through the bus conductor, A
R	is the direct-current resistance at the operating temperature, Ω/m [Ω/ft]
F	is the skin-effect coefficient
q_s	is the solar heat gain, W/m [W/ft]
q_c	is the convective heat loss, W/m [W/ft]
q_r	is the radiation heat loss, W/m [W/ft]
q_{cond}	is the conductive heat loss, W/m [W/ft]

The conductor's rapid temperature rise and its inability to dissipate the heat as quickly as it is generated under fault conditions also limit the fault current that the conductor can carry. The short circuit current allowable for aluminum conductors is calculated using Equation (2),

$$I = C \times 10^6 A_c \sqrt{\frac{1}{t} \log_{10}\left(\frac{T_f - 20\,^\circ\text{C} + (15\,150/G)}{T_i - 20\,^\circ\text{C} + (15\,150/G)}\right)} \qquad (2)$$

where

C	is 2.232×10^{-4} A $s^{0.5}$ /mm^2 for A_c in mm^2 (0.144 A $s^{0.5}$ /in^2 for A_c in in^2)
I	is the maximum allowable root-mean-square (RMS) value of fault current, A
A_c	is the conductor cross-sectional area, mm^2 (in^2)
G	is the conductivity in percent International Annealed Copper Standard (IACS)
t	is the duration of fault, s
T_f	is the allowable final conductor temperature, °C
T_i	is the conductor temperature at fault initiation, °C

The following design parameters are required to determine the current capacity for the 12.5kV main bus of Forest Grove, and Thatcher substations:

Parameter	Value
Max. load	ONFA2 transformer rating, 37.3MVA, 1723 A
Max. fault current at 20MVA base	15.4kA
Max. operating voltage	12.5kV

Fault clearing time	0.25 s
Operating bus temperature	90°C
Max. allowable temperature	250°C
Min./max. ambient temperature	0°C/40°C
Latitude/longitude (Forest Grove, Oregon)	45° N, 123° W
Altitude above sea level (Forest Grove, Oregon)	62 m (203 ft)
Atmospheric	Clear

From Table B.4 of IEEE Std. 605, with sun, 0.5 emissivity, and a temperature rise of 50°C at an ambient temperature 40ºC, a 76.2 mm (3 in) SPS schedule 40 aluminum tube has an ampacity of 2284 A. This conductor is selected as a trial size, and the ampacity will be checked for the design parameters using calculation.

Solar heat gain, q_s	30.032 W/m
Convective heat loss, q_c	130.928 W/m
Radiation heat loss,q_r	61.48 W/m
Conductive heat loss, q_{cond}	Negligible
DC resistance at the operating temperature, R	0.0000273 Ω/m
Skin-effect coefficient, F	1

Substituting the calculated values, q_s, q_c, q_r and R in Equation (1), the allowable current is 2437A. As a result, the 3 in. SPS (OD 3.5 in.), schedule 40 aluminum tubular bus having an ampacity of 2437A is suitable to carry the maximum load current of 1723A.

The next step is to verify if the conductor can withstand the maximum fault current 15.4kA. Variables for conductor short circuit current calculations are listed as below:

Variable	Description	Value
C	Constant	2.232×10^{-4}
G	Conductivity	55% for aluminum rigid bus
t	Fault clearing time	0.25s
T_f	Max. conductor temperature	250°C
T_i	Initial conductor temperature	90°C
A_c	Conductor cross-sectional area	1437.72 mm^2

Applying those variable values in Equation (2), the allowable short circuit current is calculated as 261kA which is above the limit of 15.4kA.

In conclusion, the 3 in. SPS (OD 3.5 in.), schedule 40 aluminum tubular bus is adequately rated for the maximum load current as well as the short circuit current subject to those specified parameters and operating condition.

APPENDIX F SUBSTATION EQUIPMENT SUMMARIES

Below are tables of all the critical equipment for the Filbert, Forest Grove, and Thatcher substations and their remaining life. Equipment includes power transformers, circuit switchers, feeder breakers, and voltage regulators.

Table F-1. Filbert Substation Equipment Summary.

Equipment number	Manufacturer	Model number	Year of manuf.	Description	Age (Yrs)	Remaining Life (Yrs)
Filbert Sub						
FB T1	Hevi- Duty	5473324T00	1983	Power transformer	39	1
FB-1501	Mitsubishi	100-SFMT-40E-1	2020	Feeder breaker	2	28
FB CS-1	Southern States	CSV	2020	Circuit switcher	2	28
FB-1251	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1206	ABB	R-1	1999	Feeder breaker	23	7
FB-1208	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1209	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1210	Westinghouse	R-1	1984	Feeder breaker	38	-8
FB-1241	ABB	RMAG	2005	Main breaker	17	13
FB RG-1 (A)	Siemens	JFR	*1993	Voltage regulator	29	-9
FB RG-1 (B)	Siemens	JFR	*1993	Voltage regulator	29	-9
FB RG-1 (C)	Siemens	JFR	*1993	Voltage regulator	29	-9

Table F-2. Forest Grove Substation Equipment Summary.

Equipment number	Manufacturer	Model number	Year of manuf.	Description	Age (Yrs)	Remaining Life (Yrs)
FG T1	Virginia Transformer	48020MA033U	2015	Power transformer	7	33
FG T2	Virginia Transformer	48020MA033U	2015	Power transformer	7	33
FG CS-1	Southern States	CSV	2017	Circuit Switcher	5	25
FG CS-2	Southern States	CSV	2017	Circuit Switcher	5	25
FG-1201	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1202	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1203	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1204	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1205	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1206	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1207	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1208	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1242	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1251	Mitsubishi	17DV25	2017	Feeder Breaker	5	25
FG-1252	Mitsubishi	17DV25	2017	Feeder Breaker	5	25

Table F-3. Thatcher Substation Equipment Summary.

Equipment number	Manufacturer	Model number	Year of manuf.	Description	Age (Yrs)	Remaining Life (Yrs)
TJ T1	Virginia Transformer	48020MA033U	2015	Power transformer	7	33
TJ CS-1	Southern States	CSV	2017	Circuit Switcher	5	25
TJ-1201	Mitsubishi	17DV25	2015	Feeder Breaker	7	23
TJ-1202	Mitsubishi	17DV25	2015	Feeder Breaker	7	23
TJ-1203	Mitsubishi	17DV25	2015	Feeder Breaker	7	23
TJ-1204	Mitsubishi	17DV25	2015	Feeder Breaker	7	23
TJ-1241	Mitsubishi	17DV25	2015	Feeder Breaker	7	23
TJ-1251	Mitsubishi	17DV25	2015	Feeder Breaker	7	23

APPENDIX G AVAILABLE COMMERCIAL & INDUSTRIAL SITES

CITY OF FOREST GROVE

August 2021

AVAILABLE COMMERCIAL & INDUSTRIAL SITES

I. Industrial Land

Location	Type	Size	Price	Contact
910 NW Martin Road	Zoned General Industrial (after annexation)	20.02 acres 17 acres pre-certified by state Access to State Hwy 47 Within UGB.	**Land for Sale** $6/SF $5,232,427 gross https://www.macadamforbes.com/listings/508166-sale.html	**Joe Curran** 503-9727276 Macadam Forbes jcurran@macadamforbes.com
1521 Poplar St. TTM Industrial Park	**Zoned Light Industrial**	**35 acres Can be subdivided State Certified Shovel Ready Site Flexible design; Rail served**	**For Sale or Build to Suit $5 - $6 sf** https://listingsprod.blob.core.windows.net/ourlistings-usa/34a9fb39-c478-4333-9c73-ef1506e23a11/38aae7ee-f3a2-4ac0-855a-15eaf79ed1ca	**Mark McClung** Vice-President Colliers International 503-499-0066 Mark.mcclung@colliers.com **Oregon Prospector**
2400 Yew Street / 4110 24th Avenue Henningsen Site	**Zoned General Industrial**	**4 - 20 acres**	**For Lease- Build to Suit Negotiable**	**Guy Storms Henningsen Co. (503) 359-1100 Guy.storms@henningsen.com Oregon Prospector**
600 Elm Street	**Zoned Business Industrial for Light Industrial. Office, flex space, warehousing, R&D, data centers**	**38.6 acres Business Oregon Shovel Ready Certified Site.**	**Land for Sale 38.6 acres $6.25/sf https://www.macadamforbes.com/listings/542895-sale.html**	**Joe Curran, Macadam Forbes** 503-972-7276 jcurran@macadamforbes.com **Rhys Conrad, Macadam Forbes** 503-972-7293 rhys@macadamforbes.com
Elm Street	**Zoned General Industrial**	**3.83 acres Rectangular site Site adjacent to short line rail**	**For Sale $5.50/sq. ft.**	**Mark Hush (503)542-4349 Dan Slevin Capacity Commercial Group (503) 326-9000 www.capacitycommercial.com**

I. Industrial Land Continued

Location	Type	Size	Price	Contact
2345 Quince Street 24th Avenue	Zoned General Industrial	1.50 acres Level, rocked and ready. Easy highway access	Land for Sale $350,000	Brad Young 503-860-4544 direct (503) 648-1169 office http://bradyoung.mywindermere.com
4114 Heather Street	Manufacturing, Distribution. Zoned Light Industrial	Land Available 16 acres: flat, square. All utilities to site.	For lease or sale: Land only: $2.275M	Skip Rotticci Colliers 503-499-0062 direct 503-314-0527 cell Skip.rotticci@colliers.com

II. Industrial Land & Buildings

Location	Type	Size	Price	Contact

III. Industrial Buildings

Location	Type	Size	Price	Contact
2331 – 23rd Avenue	Warehouse, Industrial, Assembly Zoned General Industrial, Food Processing	Limited sq. ft. available sub-dividable Custom space sizes 22' ceilings, rail spur, wastewater treatment facility on site	For Lease: Negotiable Space sized to suit	Gene Zurbrugg 503-681-0912 gene@zurbruggconstruction.com Oregon Prospector
3700 - 24th Ave	Manufacturing, Warehouse, Flex space Zoned General Industrial	Light Industrial and Office space Open space layout Elevator served second floor	For Lease 15,000 sf	Will Stone Marcus & Millichap 503-200-2025 Will.stone@marcusmillichap.com
3900 24th Ave	Manufacturing Building with Income. Zoned General Industrial	34,000 sf main building plus 5,000 sf storage. Main building: 30,000 sf warehouse/ manufacturing; 4,000 sf office. Clear height 24' peak; grade level loading	For Sale $5,300,000 https://km-ndp-media-repository.s3.us-west-2.amazonaws.com/kmconnect/LISTING/11026728/FLYER.pdf	Cliff Finnell Kidder Matthews 503-221-2295 Cliff.finell@kidder.com

4124 24th Ave Henningsen Cold Storage	Flex. Warehouse/distribution Cold storage	Up to 35,000 sq. ft. Sub-dividable to 2,000 sq. ft. Freezer/cooler/storage space. Truck & rail docks Two mech. rooms, freezing capacity	For lease Negotiable	Guy Storms Henningsen Co. (503) 359-1100 guy.storms@henningsen.com www.henningsen.com Oregon Prospector
2345 Quince SOLD	Manufacturing, Warehouse, Flex space Zoned General Industrial	2 buildings, 2 acre site. 23,990 sq. ft. total 1) 9,059 sq. ft. metal bldg., grade doors, 30' ceiling and overhead crane. 2) 14,970 sq. ft. 2-story 5,450 sq. ft. stacked office space with 6,120 sq. ft. warehouse and 3,400 sq. ft. attached storage	For Sale $2.2 million For Lease month-to-month only 2,300 sf 2nd floor office 900 sf warehouse space	Ted Anderson US Commercial Real Estate 503-348-6801 ted@uscre1.com www.uscre1.com Katie Heinman 503-319-1895

IV. Commercial/Retail Land

Location	Type	Size	Price	Contact
1525 Thatcher Road	Zoned CPD, commercial planned development	3.2 acres located between Thatcher Rd & Gales Ck (Hwy 8) High growth residential area.	For Sale $1.9 million	Cindy Sturm Sturm Real Estate (503) 356-8767 cindysturm@frontier.com
1940 Filbert Street	Commercial, retail, service, office, mixed use. Zoned Community Commercial	.57 acres Corner lot, cleared. Pacific Ave frontage	For Sale $425,000 http://jessedill.kwrealty.com/listing/mlsid/210/propertyid/18222834/	Jesse Dill KW Realty 503-969-3236 jessedill@kwrealty.com
2704 19th Place	Commercial, retail, service, office, mixed use. Zoned community commercial	.32 acre Flat, cleared parcel	For Sale Possible terms	503-661-5252
2806 19th Ave	Commercial, retail, service, office, mixed use. Zoned community commercial	Four 3,000 sq. ft. suites or 12,000 sq. ft. total on 1 acre site.	Offices Build to Suit	Mike Hundley (503) 359-4421 mhundley@farmersagent.com

IV. Commercial/Retail Land Continued

Location	Type	Size	Price	Contact
2812 19th Ave	Commercial, retail, service, office, mixed use. Zoned community commercial	.19 acre 58' x 140' lot Contains home	For Sale $169,900. Can be sold with adjoining 2820 19th Ave	Douglas Boscamp (503) 319-3436 NW Realty Group (503) 620-3100 www.DouglasBoscamp.com
2820 19th Ave	Commercial, retail, service, office, mixed use. Zoned community commercial	.28 acre 60' x198' lot Contains home	For Sale $159,900 Can be sold with adjoining 2812 19th Ave	Douglas Boscamp (503) 319-3436 NW Realty Group (503) 620-3100 www.DouglasBoscamp.com
2624 Pacific Avenue	Zoned Community Commercial. Retail, service, office	1 acre Frontage on Pacific Avenue	Land for lease Price negotiable	Stacia Truax (503) 546-3535
3600 Pacific Ave	Zoned community commercial. Retail, service, office	Stonewood Center Commercial Development Site. .95 AC (41,150 sf)	For Sale or Build to Suit https://www.colliers.com/en/properties/for-sale-or-build-to-suit-095-ac-land-in-forest-grove-3600-pacific-ave/usa-3600-pacific-avenue-forest-grove-or-97116/usa1093319#RelatedDocs	Skip Rottici Colliers 503-499-0062 Skip.rotticci@colliers.com
3653 Pacific Avenue Urgent Care here	Zoned Community Commercial. Retail, service, office	Commercial Redevelopment Land: 1.85 acres, 4 lots Fronts Pacific Avenue with large parking area; highway frontage	For Sale: $30/sf land $2,148,000 total https://www.loopnet.com/Listing/3653-Pacific-Ave-Forest-Grove-OR/20696011/?stid=melvinmarkco	Don Drake Melvin Mark Company O: 503-546-4527 C: 503-789-8688 drake@melvinmark.com
4202 Pacific Ave	Zoned Community Commercial. Retail, service, office, mixed	37,800 sq. ft. buildable lot Dairy Queen	For Lease or Build to Suit	(503) 235-5906 Mogrewal1@gmail.com
4233 Pacific Ave	Zoned community commercial. Retail, service, office	2.5 acres commercial land Pacific Ave frontage	Land for Lease	Michael Doherty (503) 357-3114

V. Commercial/Retail Buildings

Location	Type	Size	Price	Contact
1940 Pacific Avenue	Zoned Town Center Core. Retail, Office, Commercial, Residential Apts	Former US Bank Building 9,808 sf; Existing drive through lanes, 16 onsite parking spaces	For Sale $1,550,000 Flyer	Gary Griff Cushman & Wakefield 503-279-1756 Gary.griff@cushwake.com
1927 & 1931 Main Street	Zoned Town center core. Retail, commercial, service.	4,792 sq. ft. Former restaurant on one side and former bar on the other. Kitchen intact.	For Sale $675,000	Matt Williams Century 21 Northwest 503-316-5823 www.mattwilliams.c21.com
2020 Main Street	Zoned Town center core. Signature Building in downtown, Corner Main/Pacific	2-story with mezzanine historical commercial building. Currently vacant. 10,000sf large space on 1st floor. Good potential for apts/lodging on 2nd floor	For Sale $975,000	Jaque Tinoco 971-777-0094 Jaquetinoco.1@gmail.com
1837 Pacific Ave Jesse Quinn Apts	Zoned Town Center Transitional. Retail, commercial, residential	One Live/Work loft space #113 Redwood Floor plan	For Lease 867 sq. ft. $1,295/month	Eileen Filippelli Property Manager 503-530-8556 jessequinn@tokolaproperties.com
1917 Pacific Ave.	Zoned central business District, Commercial, office, service	2nd Floor: two 1,000 sq. ft. suites 2,000 sq. ft. total;	For lease: 2nd floor: negotiable/NN	Chet Wolter ProSteel Builders (503) 647-2011
2305 Pacific Ave & 2003 Cedar Street	Zoned Town Center Transitional: Retail, service, commercial	Two suites in corner lot on Pacific/Cedar Street in busy Forest Grove shopping Center Two suites: Suite B 680 SF Suite D 1,800 SF	For Lease $12 PSF/Month + Electric & Prorated taxes	Tim Budelman Norris @ Stevens 503-225-8472 TimB@norris-stevens.com https://www.norris-stevens.com/commercial-properties/all/?propertyId=2003-cedar-street
2315 Pacific Avenue	Zoned Town Center Transitional: Retail, service, commercial	Two suites: 1,000 sf 4,000 sf	For Lease $15 sf/year NNN	Pam Rushing 503-804-0457 Mtn West Real Estate/Coldwell Banker Comm'l www.cbre.com
2328 Pacific Ave	Zoned Community Commercial -retail, service, office	3 to 5 100 sq. ft. suites	For Lease $250/mo gross	Cindy Sturm Sturm Real Estate cindysturm@frontier.com (503) 356-8767
2801 Pacific Ave	Office/service/retail Commercial or professional	Frontage on Pacific Ave	Space for lease 1,350sf Negotiable/flexible	Steve Schmitz 503-490-3400 Steve1pdx@gmail.com

V. Commercial/Retail Buildings continued

Location	Type	Size	Price	Contact
2835 Pacific Avenue	Zoned Community Commercial -retail, service, office	Two commercial suite for lease Suite 1 3,000 sq. ft Suite 2 2,500 sq. ft. Suites can be combined. Each have own bathroom.	For Lease $1/sf plus property taxes Suite 1 $3,000+ Suite 2 $2,500+	Kenny 503-475-4803
3127 Pacific Ave	Zoned Community Commercial -retail, service, office	8,000sf building. Total site is 1.54 acres, Wood framed, clean site. Pacific Ave across from Maple Street. Currently leased short term	For Sale or Lease. Negotiable. Contract sale possible	Joel Groshong 601-341-3832 601-783-6336
3322 Pacific Avenue	Zoned Community Commercial: office, retail, service	Stand-alone building	For Lease	Ed Hayden Hayden Group, LLC 503-648-6445
3438 Pacific Avenue	Zoned Community Commercial: retail, service, commercial	Pacific Oak Development 3,000 sf. Pacific Avenue frontage; new construction for occupancy winter/spring 2021	For Lease NNN 3,000 sf	Pacific Development Ventures 503-201-1309
3602 Pacific Avenue	Zoned Community Commercial; office, retail, service	The Stonewood Center New Development. Mixed-use retail center 2,956 sf divisible to 1,246 & 1,710 sf.	Commercial/retail space to lease $26.50/sf + NNN	Rob Moneyhan Urbanworks (503) 228-3080 www.urbanworksrealestate.com
2031 Hawthorne St	Office/service Commercial or Professional service.	Maywood Buildings Dedicated parking on site. Handicap Access	Office space for lease Suite C: 1,410 sq. ft. Suite G: 1,256 sq. ft.	Tim Budelman Norris & Stevens (503) 225-8472 (503) 710-1253 www.norris-stevens.com
2811 19th Avenue	Zoned Community Commercial; office, retail, service	4,000 sf Can be subdivided; has drive-up window; former bank building	For Lease $4,500/mo NNN	Gene Horton 503-747-8385 gene@hortonos.com

APPENDIX H ESTIMATED LOAD DEMAND FOR AVAILABLE COMMERCIAL & INDUSTRIAL SITES

Below are the available commercial and industrial sites from Appendix G, along with their average maximum energy usage. Data was provided by the U.S. Energy Information Administration for the year 2012, released in December 2016. The total demand from all available commercial and industrial sites with estimated energy usage values is 1.35 MW, not including the available general and light industrial zones. Thus, 2-3 MW is the estimated total demand from all available commercial and industrial sites.

Table H-1. Available Industrial Land Sites and their maximum energy usage.

Industrial Land					
Location	**Type**	**Size**	**Yearly Energy Usage**	**Max Energy Usage (kWh)-Yearly**	**Max Energy Usage (kWh)-Hourly**
910 NW Martin Road	Zoned General Industrial (after annexation)	20.02 acres 17 acres pre-certified by state Access to State Hwy 47 within UGB			
1521 Poplar St. TTM Industrial Park	Zoned Light Industrial	35 acres Can be subdivided State Certified Shovel Ready Site Flexible design; Rail served			
2400 Yew Street / 4110 24th Avenue Henningsen Site	Zoned General Industrial	4-20 acres			
600 Elm Street	Zoned Business Industrial for Light Industrial. Office, flex space, warehousing, R&D, data centers	38.6 acres Business Oregon Shovel Ready Certified Site.			
Elm Street	Zoned General Industrial	3.83 acres Rectangular Site Site adjacent to short line rail			
2345 Quince Street 24th Avenue	Zoned General Industrial	1.50 acres Level, rocked and ready. Easy highway access			
4114 Heather Street	Manufacturing, Distribution, Zoned Light Industrial	Land Available 16 acres: flat, square. All utilities to site.	5.4 kWh/sf	3763584	429.6

Table H-2. Available Industrial Building Sites and their maximum energy usage.

Industrial Buildings					
Location	**Type**	**Size**	**Yearly Energy Usage**	**Max Energy Usage (kWh)-Yearly**	**Max Energy Usage (kWh)-Hourly**
2331-23rd Avenue	Warehouse, Industrial, Assembly Zoned General Industrial, Food Processing	Limited sq. ft. available sub dividable Custom space sizes 22' ceilings, rail spur, wastewater treatment facility on site			
3700-24th Ave	Manufacturing, Warehouse, Flex space Zoned General Industrial	Light Industrial and Office space Open space layout Elevator served second floor			
3900 24th Ave	Manufacturing Building with Income. Zoned General Industrial	34,000 sf main building plus 5,000 sf storage. Main building: 30,000 sf warehouse/ manufacturing; 4,000 sf office. Clear height 24' peak; grade level loading	13.7 kWh/sf 6.6 kWh/sf	285800	32.6
4124 24th AveHenningsen Cold Storage	Flex. Warehouse/ distribution Cold storage	Up to 35,000 sq. ft.Sub-dividable to 2,000 sq. ft.Freezer/cooler/storage space.Truck & rail docksTwo mech. Rooms, freezing capacity	28.8 kWh/sf	1008000	115.1

Table H-3. Available Commercial/Retail Land Sites and their maximum energy usage.

Commercial/Retail Land					
Location	**Type**	**Size**	**Yearly Energy Usage**	**Max Energy Usage (kWh)-Yearly**	**Max Energy Usage (kWh)-Hourly**
1525 Thatcher Road	Zoned CPD, commercial planned development	3.2 acres located between Thatcher Rd & Gales Ck (Hwy 8) High growth residential area	16.9 kWh/sf	2355725	268.9
1940 Filbert Street	Commercial, retail, service, office, mixed use. Zoned Community Commercial	.57 acres Corner lot, cleared. Pacific Ave frontage	13.7 kWh/sf	340160	38.8
2704 19th Place	Commercial, retail, service, office, mixed use. Zoned Community Commercial	.32 acre Flat, cleared parcel	13.7 kWh/sf	190967	21.8
2806 19th Ave	Commercial, retail, service, office, mixed use. Zoned Community Commercial	Four 3,000 sq. ft. suites or 12,000 sq. ft. total on 1 acre site.	13.7 kWh/sf	164400	18.8
2812 19th Ave	Commercial, retail, service, office, mixed use. Zoned Community Commercial	.19 acre 58' x 140' lot Contains home	13.7 kWh/sf	113386.7	12.9
2820 19th Ave	Commercial, retail, service, office, mixed use. Zoned Community Commercial	.28 acre 60' x 198' lot Contains home	13.7 kWh/sf	167096.2	19.1
2624 Pacific Avenue	Zoned Community commercial. Retail, service, office	1 acre Frontage on Pacific Avenue	13.7 kWh/sf	596772	68.1
3600 Pacific Ave	Zoned Community commercial. Retail, service, office	Stonewood Center Commercial Development Site. .95 AC (41,150 sf)	13.7 kWh/sf	563755	64.4
4233 Pacific Ave	Zoned Community commercial. Retail, service, office	2.5 acres commercial land Pacific Ave frontage	13.7 kWh/sf	1491930	170.3

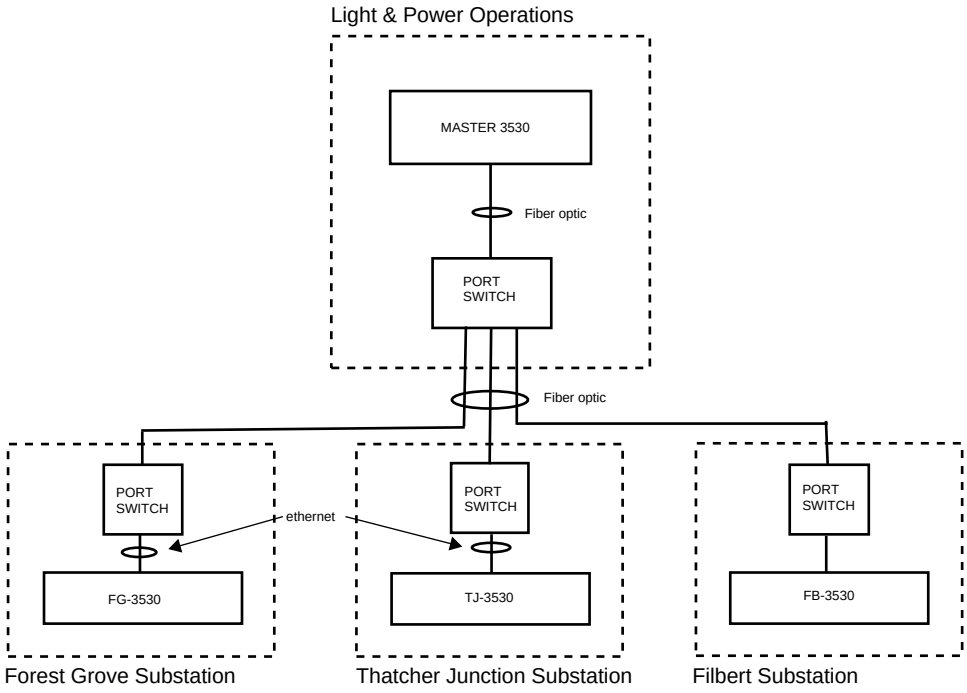
Table H-4(a). Available Commercial/Retail Building Sites and their maximum energy usage.

Commercial/Retail Buildings					
Location	**Type**	**Size**	**Yearly Energy Usage**	**Max Energy Usage (kWh)-Yearly**	**Max Energy Usage (kWh)-Hourly**
1940 Pacific Avenue	Zoned Town Center Core. Retail, Office, Commercial, Residential Apts	Former US Bank Building 9,808 sf; Existing drive through lanes, 16 onsite parking spaces	13.7 kWh/sf	132999.6	15.2
1927 & 1931 Main St.	Zoned Town Center Core. Retail, Commercial, service.	4,792 sq. ft. Former restaurant on one side and former bar on the other. Kitchen intact.	13.7 kWh/sf	65650.4	7.5
2020 Main Street	Zoned Town Center core. Signature Building in downtown, Corner Main/Pacific	2-story with mezzanine historical commercial building. Currently vacant. 10,000 sf large space on 1st floor. Good potential for apts/ lodging on 2nd floor	16.9 kWh/sf	169000	19.3
1837 Pacific Ave Jesse Quinn Apts	Zoned Town Center Transitional. Retail, commercial, residential	One Live/Work loft space #113 Redwood Floor plan	13.7 kWh/sf		
1917 Pacific Ave.	Zoned central business District, Commercial, office, service	2nd Floor: two 1,000 sq. ft. suites 2,000 sq. ft. total	13.7 kWh/sf	27400	3.1
2305 Pacific Ave & 2003 Cedar Street	Zoned Town Center Transitional. Retail, commercial, residential	Two suites in corner lot on Pacific/ Cedar Street in busy Forest Grove shopping Center Two suites: Suite B 680 SF Suite D 1,800 SF	13.7 kWh/sf	33976	3.9
2315 Pacific Avenue	Zoned Town Center Transitional. Retail, commercial, residential	Two suites: 1,000 sf 4,000 sf	13.7 kWh/sf	68500	7.8
2328 Pacific Ave	Zoned Community Commercial -retail, service, office	3 to 5 100 sq. ft. suites	13.7 kWh/sf	6850	0.8
2835 Pacific Avenue	Zoned Community Commercial -retail, service, office	Two commercial suite for lease Suite 1 3,000 sq. ft Suite 2 2,500 sq. ft. Suites can be combined. Each have own bathroom.	13.7 kWh/sf	75350	8.6

Table H-4(b). Available Commercial/Retail Building Sites (Cont.) and their maximum energy usage.

Commercial/Retail Buildings (Cont.)					
Location	**Type**	**Size**	**Yearly Energy Usage**	**Max Energy Usage (kWh)-Yearly**	**Max Energy Usage (kWh)-Hourly**
3127 Pacific Ave	Zoned Community Commercial - retail, service, office	8,000sf building. Total site is 1.54 acres, Wood framed, clean site. Pacific Ave across from Maple Street. Currently leased short term	13.7 kWh/sf	109600	12.5
3322 Pacific Avenue	Zoned Community Commercial: office, retail, service	Stand-alone building	13.7 kWh/sf		
3438 Pacific Avenue	Zoned Community Commercial: retail, service, commercial	Pacific Oak Development 3,000 sf. Pacific Avenue frontage; new construction for occupancy winter/spring 2021	13.7 kWh/sf	41100	4.7
3602 Pacific Avenue	Zoned Community Commercial: office, retail, service	The Stonewood Center New Development. Mixed-use retail center 2,956 sf divisible to 1,246 & 1,710 sf.	13.7 kWh/sf	40497.2	4.6
2031 Hawthorne St	Office/service Commercial or Professional service.	Maywood Buildings Dedicated parking on site. Handicap Access	16.9 kWh/sf		
2811 19th Avenue	Zoned Community Commercial; office, retail, service	4,000 sf Can be subdivided; has drive-up window; former bank building	13.7 kWh/sf	54800	6.3

APPENDIX I SUBSTATION SCADA SYSTEM ARCHITECTURES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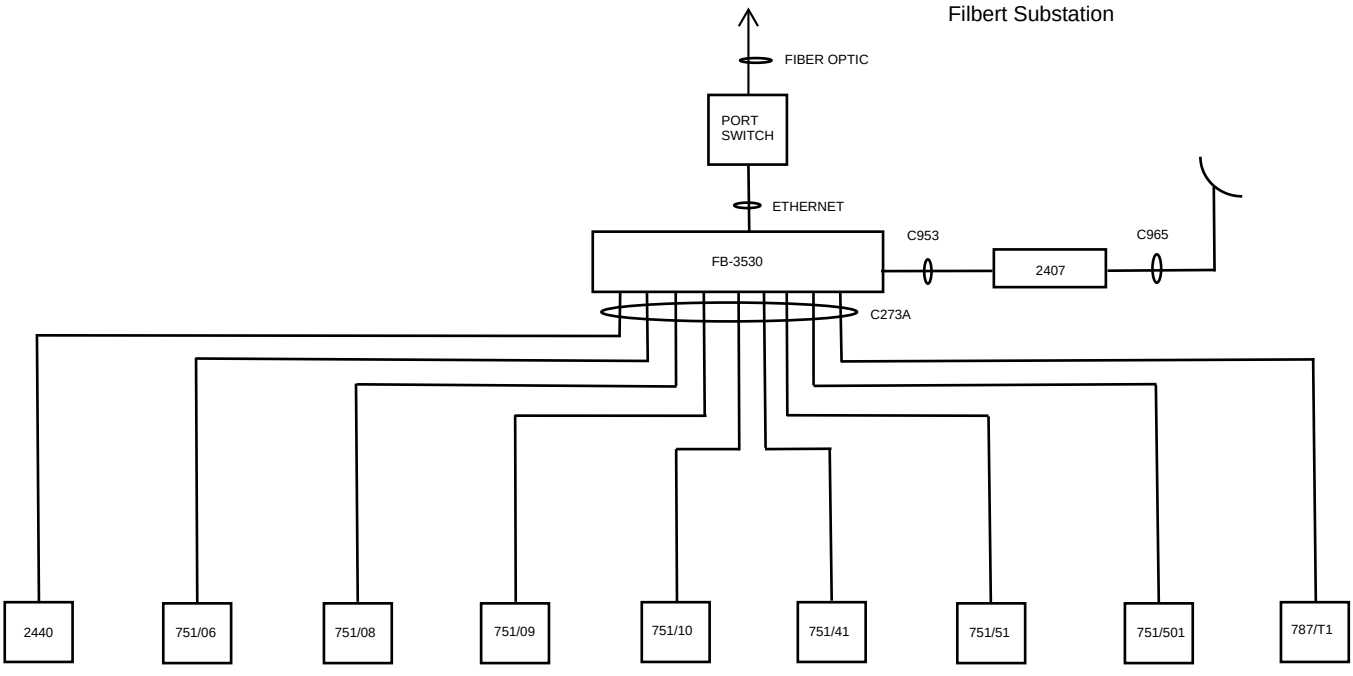
Fiber optic
PORT SWITCH
Fiber optic
PORT SWITCH
ethernet
PORT SWITCH
PORT SWITCH
FG-3530
TJ-3530
FB-3530
Forest Grove Substation
Thatcher Junction Substation
Filbert Substation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C965
C273A
2440
751/06
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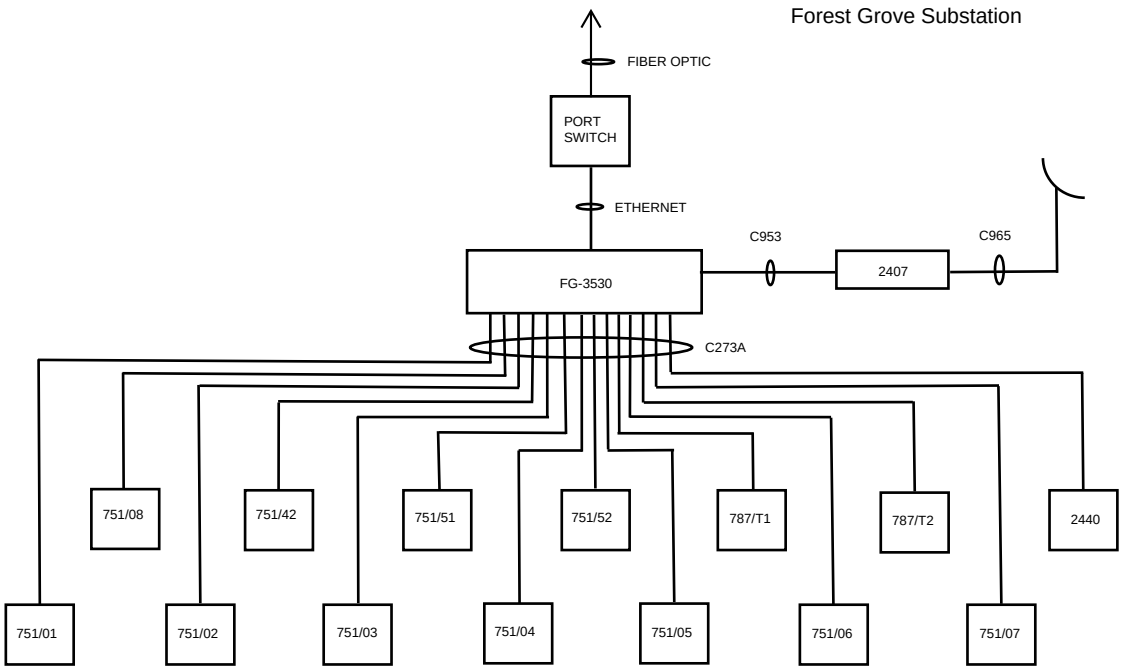
Forest Grove Substation
FIBER OPTIC
PORT SWITCH
ETHERNET
C953
C965
FG-3530
2407
C273A
751/08
751/42
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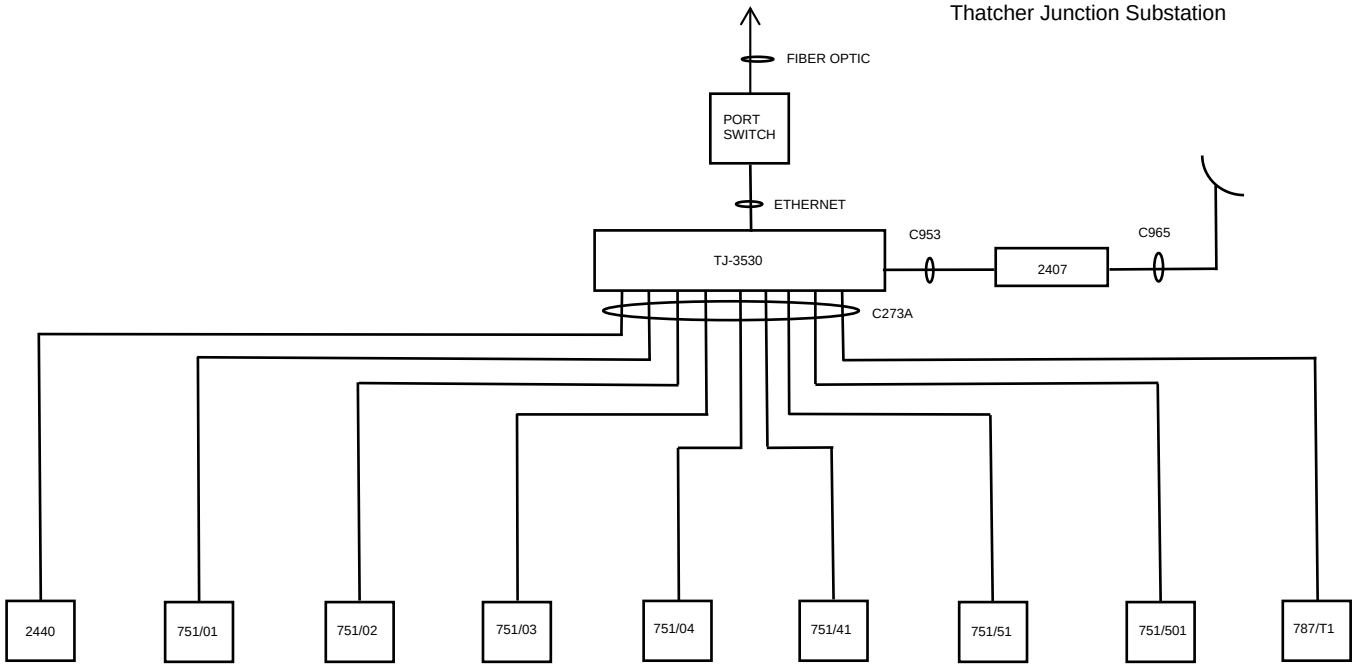
Thatcher Junction Substation
FIBER OPTIC
PORT SWITCH
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TJ-3530
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751/01
751/02
751/03
751/04
751/41
751/51
751/501
787/T1

APPENDIX J ADDITIONAL FOREST GROVE TOTAL ENERGY CHARTS

Below are total hourly energy charts from 2013-2021 for the four individual meters: Forest Grove 2, Forest Grove 1, Thatcher, and Filbert. Each contains a weekly moving Average trendline (168 hours in a week).

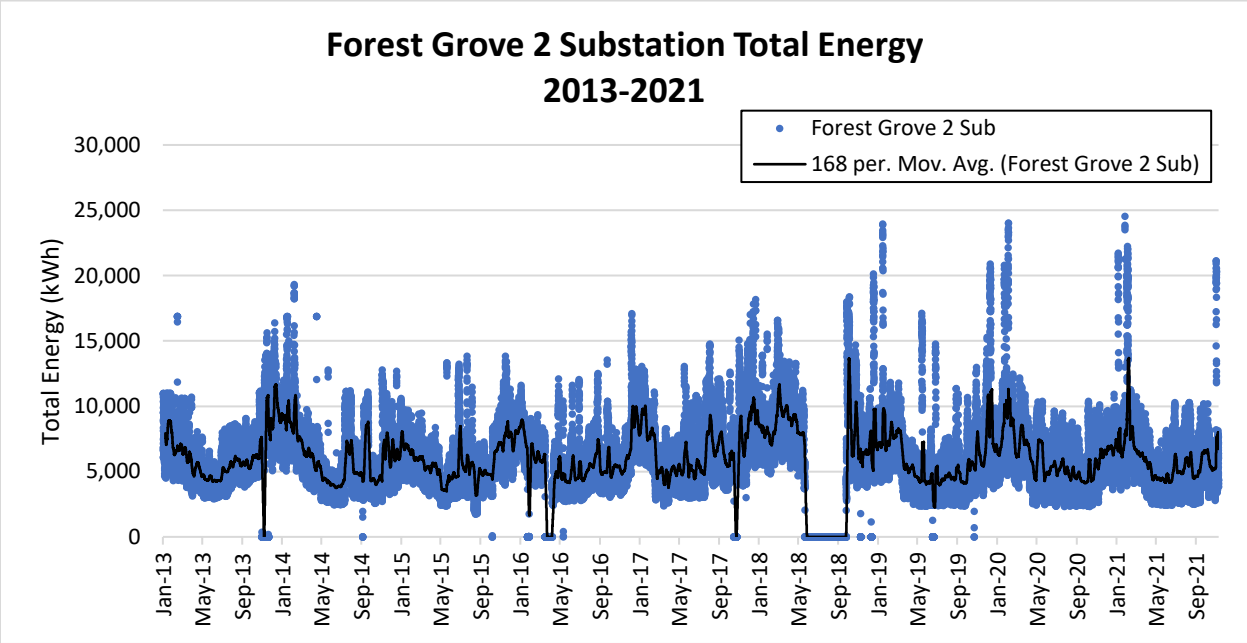

Figure J-1. Total hourly energy for the Forest Grove 2 substation from 2013-2021.

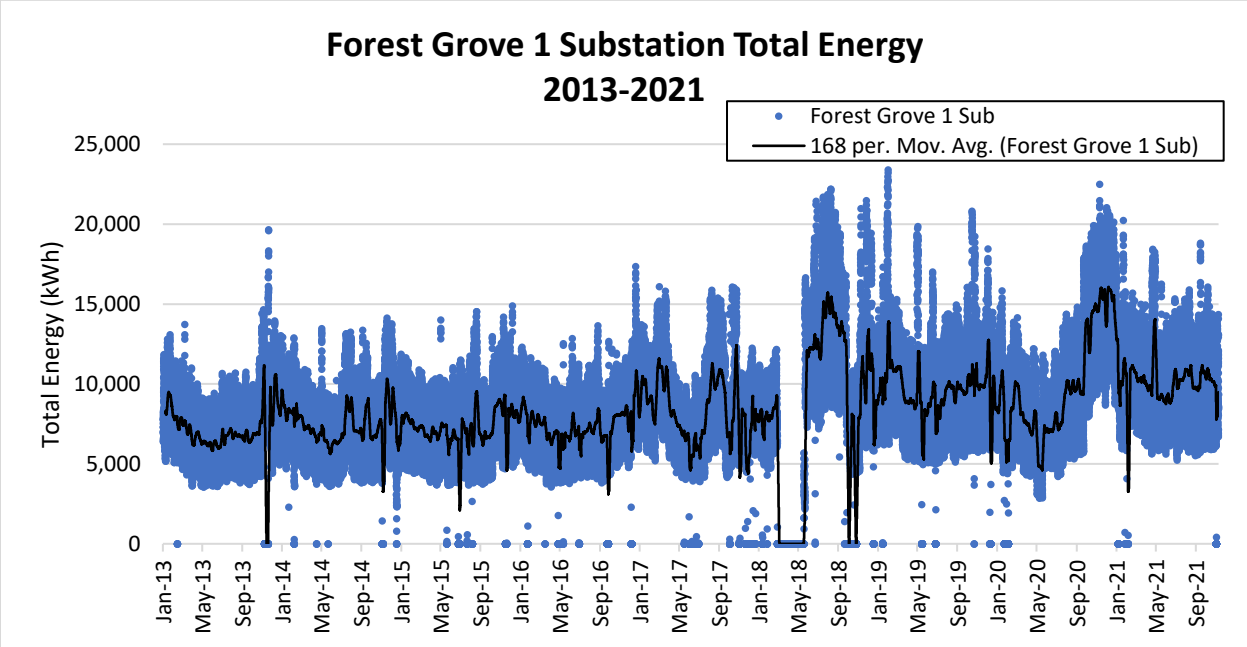

Figure J-2. Total hourly energy for the Forest Grove 1 substation from 2013-2021.

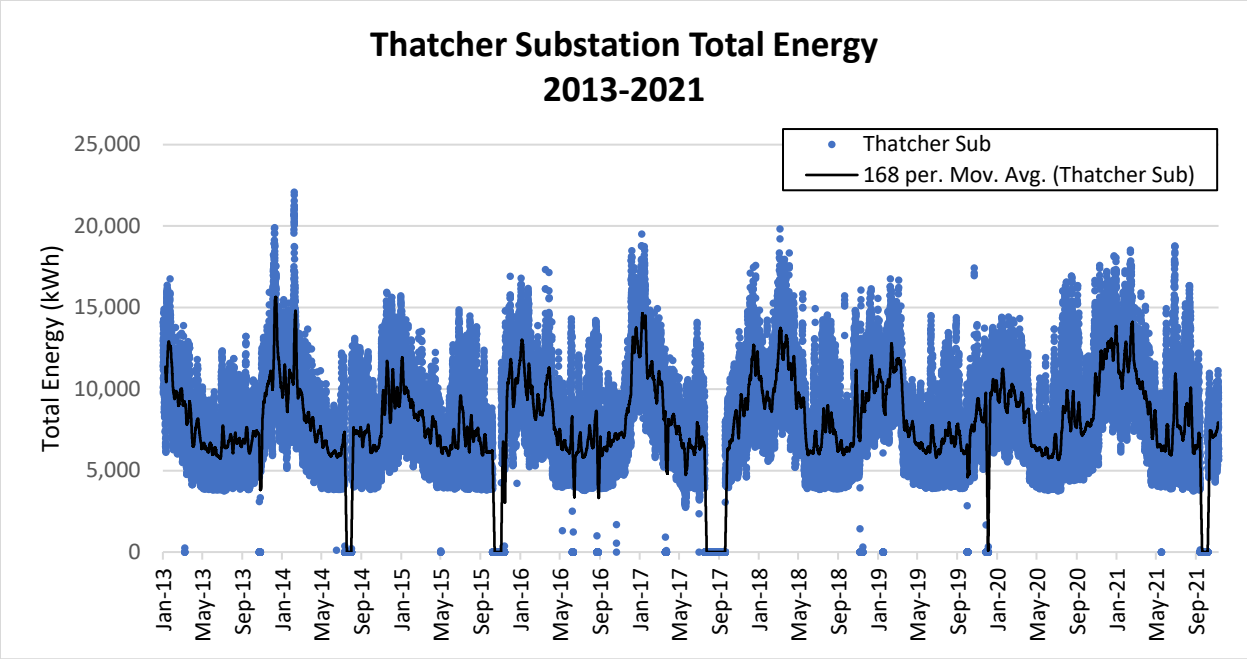

Figure J-3. Total hourly energy for the Thatcher substation from 2013-2021.

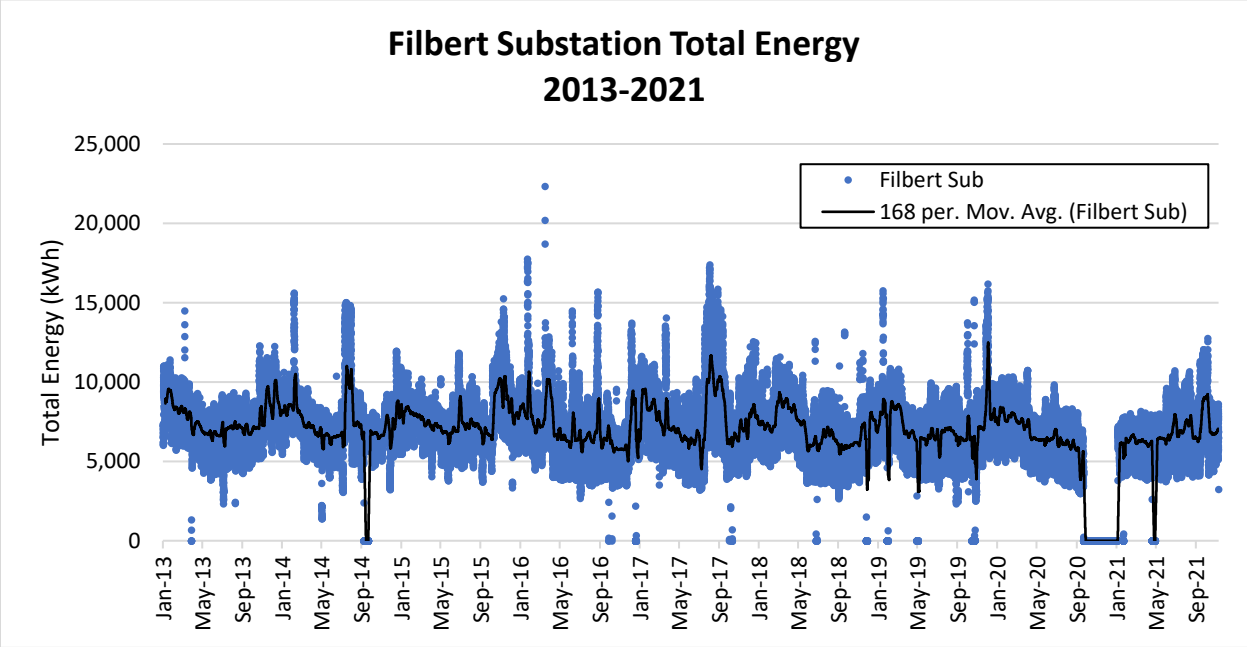

Figure J-4. Total hourly energy for the Filbert substation from 2013-2021.

In addition to visualizing the individual meters, analyzing the aggregated energy gives a more complete picture into the Forest Grove system. Below are the aggregated weekly, monthly, and yearly rolling averages, along with a linear trend yielding an average load increase per year.

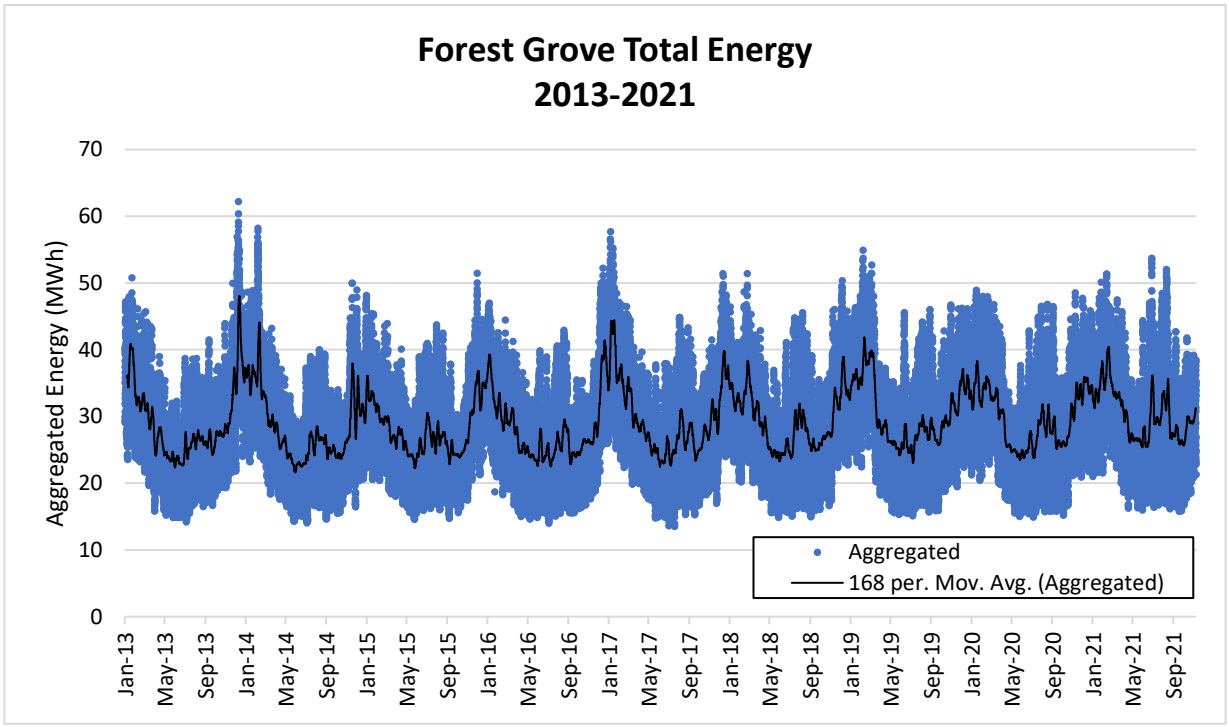

Figure J-5. Total hourly energy for the Forest Grove system from 2013-2021. The trendline shown is a weekly moving average (168 hours per week).

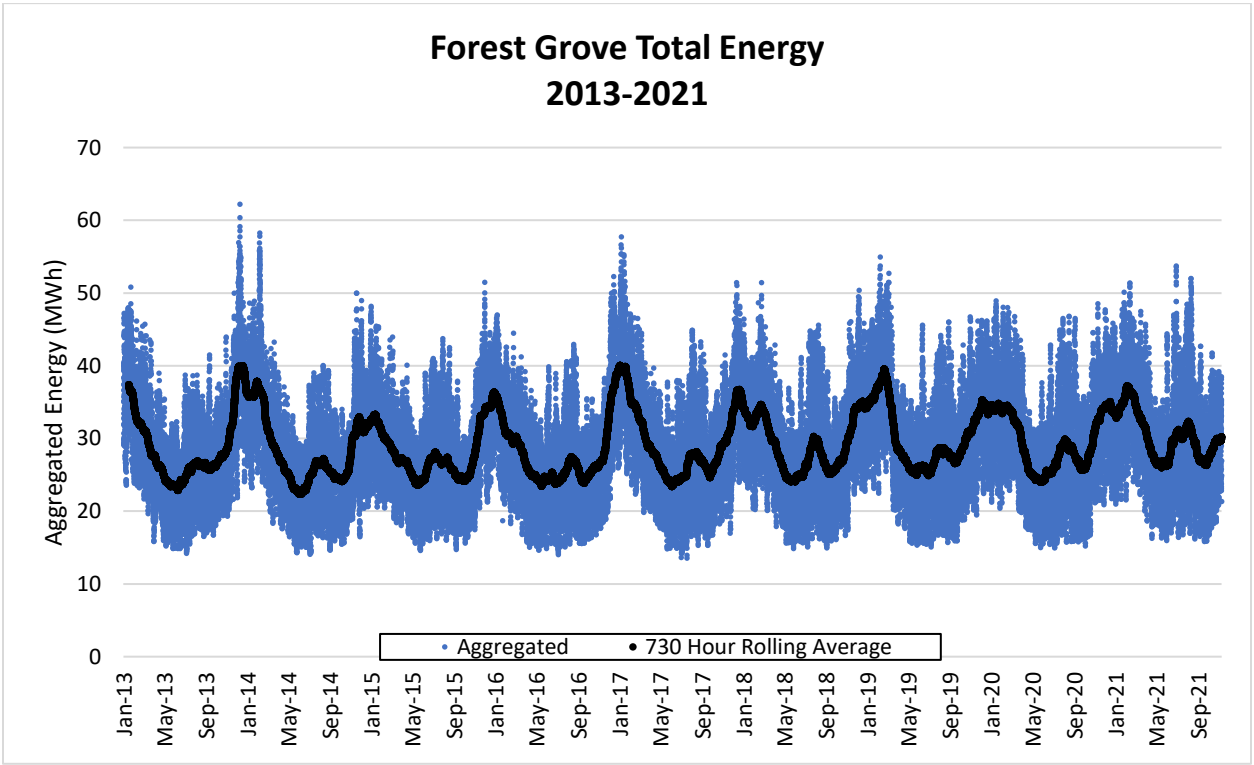

Figure J-6. Total hourly energy for the Forest Grove system from 2013-2021, along with a monthly rolling average.

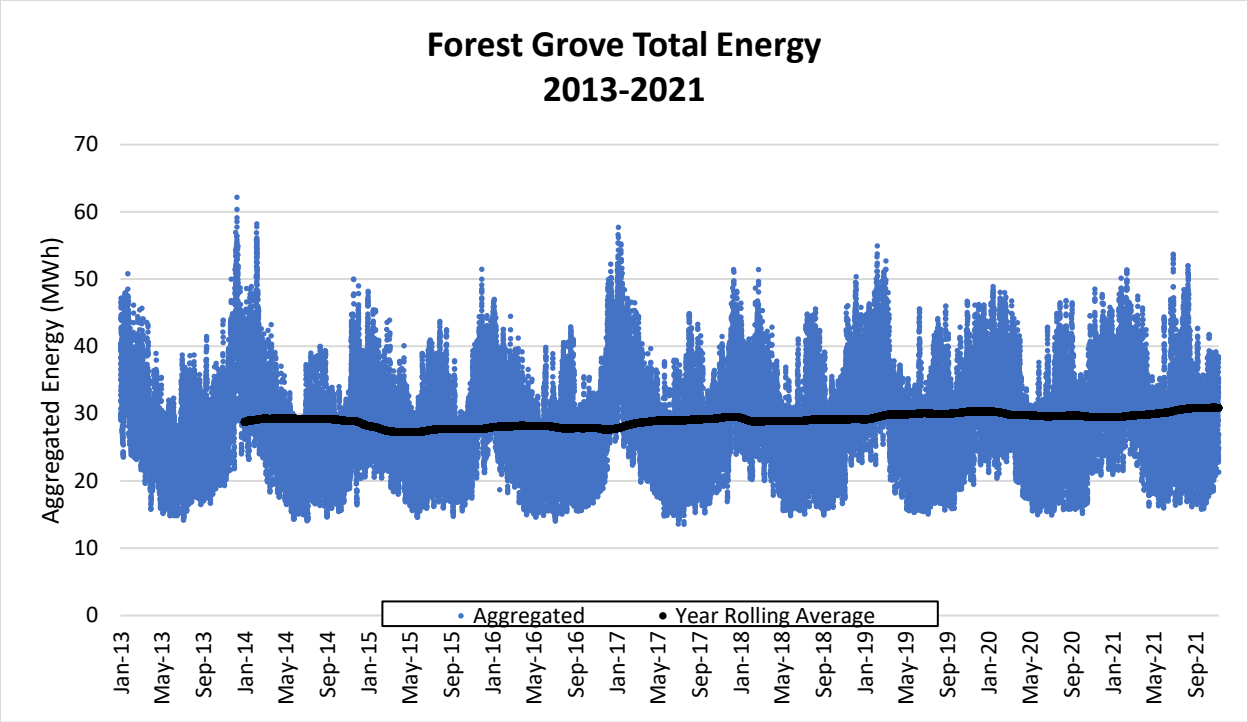

Figure J-7. Total hourly energy for the Forest Grove system from 2013-2021, along with a yearly rolling average.

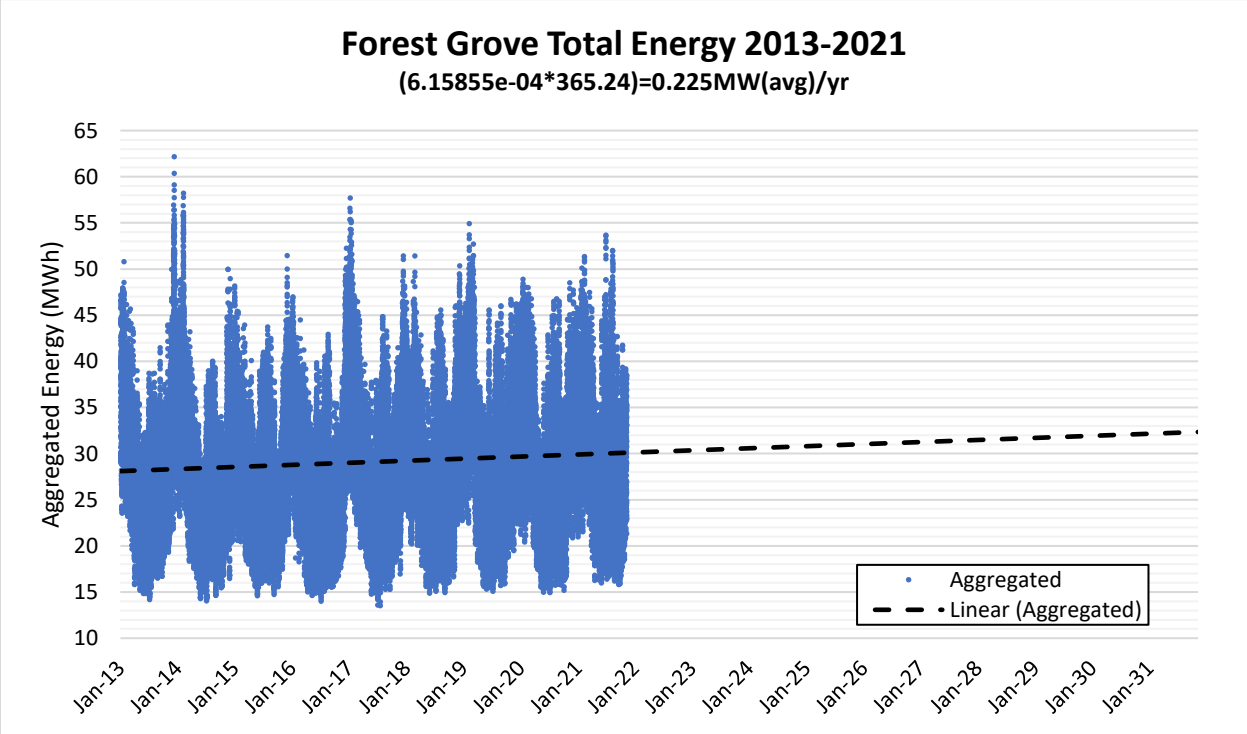

Figure J-8. Total hourly energy for the Forest Grove system from 2013-2021, along with a linear trend yielding an average increase of 0.225 MW per year.