



TRINITY PUBLIC UTILITY DISTRICT

**2022-2026
System Improvement Plan**

NOVEMBER 2021



**2022 - 2026
SYSTEM IMPROVEMENT PLAN**

for

Trinity Public Utility District

NOVEMBER 2021



Respectfully Submitted,

STAR ENERGY SERVICES LLC

*This report was written by Kristi Robinson, P.E. and Blane Walberg, EIT with
STAR Energy Services LLC under the direction of Guy Colpron, P.E. of BKI Engineering Services.*

TABLE OF CONTENTS

1	EXECUTIVE SUMMARY	1
	1.1 Introduction	1
	1.2 Summary of Projects	1
	1.3 Results of Proposed Projects	2
2	INTRODUCTION	3
	2.1 Service Area	3
	2.2 Distribution System.....	3
	2.3 Power Supplier and Transmission System	3
3	BASIS OF STUDY.....	5
	3.1 Design Criteria.....	5
	3.2 References.....	5
	3.3 Equipment Loading	5
4	LOAD ANALYSIS	7
	4.1 Purchases	7
	4.2 Losses	7
	4.3 Growth Patterns.....	8
	4.3.1 Energy Sales.....	8
	4.3.2 Peak Demand	10
	4.3.3 Load Factor	10
	4.4 System Outages and Reliability.....	10
	4.5 Advance Metering Infrastructure	13
5	REQUIRED CONSTRUCTION ITEMS	15
	5.1 New and Upgraded Services	15
	5.2 Substation Transformers.....	15
	5.3 Big Bar Substation	15
	5.4 Douglas City Substation	16
	5.5 Forest Glen Substation.....	16
	5.6 Grouse Creek Substation.....	16
	5.7 Hayfork Substation.....	16
	5.8 Hyampom Substation.....	17
	5.9 Lewiston Substation.....	17
	5.10 Mill Street Substation	18
	5.11 Trinity Substation	19
	5.12 Miscellaneous Replacements & Additions.....	19
	5.12.1 Underground Cable Replacement.....	19
	5.12.2 Pole Replacements.....	19
	5.12.3 Metering Replacements.....	19
	5.12.4 Transformer Installations.....	19
	5.12.5 Line Regulators.....	19
	5.12.6 Line Reclosers.....	19
6	COST BY CODES.....	21

LIST OF ILLUSTRATIONS

TABLES

Table 1.1	Historical and Projected Total Utility Plant Investments.....	1
Table 1.2	Summary of Costs	2
Table 2.1	Transmission Supply to TPUD Substations	3
Table 3.1	Equipment Loading Actions	6
Table 3.2	Overhead Conductor Thermal Limits.....	6
Table 4.1	Energy Purchases by Supplier	7
Table 4.2	Historical System Losses	7
Table 4.3	Monthly Energy Usage Residential and Small Commercial Classes.....	9
Table 4.4	Historical Load Data	10
Table 4.5	SAIDI Indices by Substation.....	11
Table 6.1	Substation and Transmission Changes	21
Table 6.2	Distribution Line Changes	21
Table 6.3	Miscellaneous Line Additions and Replacements.....	22
Table 6.4	Summary of Costs Breakdown	22

FIGURES

Figure 1	2020 Energy Usage by Classification.....	8
Figure 2	2020 Consumer Classification.....	9
Figure 3	2019 PG&E Substation Outage Causes	11
Figure 4	2019 WAPA Substation Outage Causes	12
Figure 5	2020 PG&E Substation Outage Causes	12
Figure 6	2020 WAPA Substation Outage Causes	13

1 EXECUTIVE SUMMARY

1.1 Introduction

This study was created to outline the proposed distribution and transmission projects for Trinity Public Utility District (TPUD) for the 2022-2026 time period. This study may be used as an interactive planning guide for TPUD for the next five years.

This study will review TPUD’s system based on current and forecast conditions, including growth patterns and distribution facilities statuses. Proposed projects will address changes in system growth, aging infrastructure, and power quality issues.

TPUD’s historical and projected annual distribution plant investments are shown in Table 1.1. The distribution capital expenditures proposed for the next four years will result in the total utility plant increasing at an average annual rate of approximately 3.6%.

Upon completion of the projects proposed in this document, TPUD’s system will continue to be able to provide adequate and reliable service its consumer base.

Table 1.1 Historical and Projected Total Utility Plant Investments

Historical and Projected Total Utility Plant				
	YEAR	TDP Beginning of Year (\$)	Distribution Change (\$)	Additions divide by TUP
Historical	2012/2013	\$ 29,253,000		0.00%
	2013/2014	\$ 29,438,000	\$ 185,000	0.63%
	2014/2015	\$ 29,306,000	\$ (132,000)	-0.45%
	2015/2016	\$ 29,714,000	\$ 408,000	1.37%
	2016/2017	\$ 30,378,000	\$ 664,000	2.19%
	2017/2018	\$ 31,996,000	\$ 1,618,000	5.06%
	2018/2019	\$ 32,837,000	\$ 841,000	2.56%
	2019/2020	\$ 35,553,000	\$ 2,716,000	7.64%
Estimated	2020/2021	\$ 35,728,000	\$ 850,000	2.38%
System	2021/2022	\$ 36,578,000	\$ 1,416,400	3.87%
Improvement	2022/2023	\$ 37,994,400	\$ 1,416,400	3.73%
Estimate	2023/2024	\$ 39,410,800	\$ 1,416,400	3.59%
	2024/2025	\$ 40,827,200	\$ 1,416,400	3.47%
	2025/2026	\$ 42,243,600	\$ 1,416,400	3.35%

The goal of this study was to provide a priority list of construction projects to address load growth and aging infrastructure issues TPUD’s distribution systems is expected to face in during the 2022-2026 time period. TPUD has experienced growth of large single-phase loads in the recent past, with additional growth expected in the future. With this growth, potential power quality issues may arise, which are also addressed within this study. Additional attention was also given to aging facilities that

have a direct impact on the reliability of the utility. A summary of the projects identified with in this study includes:

- Upgrade of Big Bar Substation transformer and high side structure.
- Upgrade of the Grouse Creek Substation structure and transformer replacement.
- Replacement of the Hyampom Substation transformer and regulators.
- Replacement of the Forest Glen Substation transformer.
- Replacement of Mill Street Substation reclosers and controls.
- 8.1 miles of three-phase overhead distribution line replacement to allow for higher capacity loads.
- An additional 28.9 miles of distribution line identified for potential overhead distribution replacement.
- A potential extension of 20 miles of 60 kV transmission.
- 5 miles of three-phase underground replacement due to deteriorating cable.
- Various additions and replacements of distribution line equipment.

1.3 Results of Proposed Projects

Upon completion of the recommended projects, TPUD will reduce system losses, provide additional capacity for current and potential new electric loads, and improve the reliability of service to its consumers. The summary of costs of the proposed projects are listed in Table 1.2.

Table 1.2 Summary of Costs

2022-2026 System Improvement Infrastructure Costs	
High Priority	
Substation & Distribution Line Projects	\$ 6,046,000
Annual Replacements	\$ 1,036,000
High Priority Projects & Replacements Total	\$ 7,082,000
Low Priority	
Substation & Distribution Line Projects	\$ 10,360,000
Low Priority Projects Total	\$ 10,360,000
High & Low Priority Projects & Replacements	\$ 17,442,000
Transmission Projects	\$ 80,000,000
All Identified Projects & Replacements	\$ 97,442,000

2 INTRODUCTION

2.1 Service Area

TPUD is a distribution cooperative that serves the majority of Trinity County in northern California. With headquarters in Weaverville, California, TPUD serves 7,322 members. The majority of the members served are in urban areas. TPUD does serve some rural areas that are mostly residential homes or agricultural businesses.

2.2 Distribution System

TPUD owns, operates, and maintains a 60 kV transmission and multiple different voltage configurations of distribution system. Included in TPUD's system is 600 miles of overhead lines, 150 miles of underground lines, and nine distribution substations. Of the nine substations, five substations are not able have a distribution circuit from a neighboring substation provide contingency at the distribution level. Douglas City, Lewiston, Mill City, and Trinity are able to provide at least partial contingency to neighboring substations. A summary of the substations owned by TPUD is shown in Table 2.1.

Table 2.1 Transmission Supply to TPUD Substations

Transmission Supply to TPUD Substations				
Substation	Primary Voltage	Secondary Voltage	Transmission Provider	Existing Capacity
Big Bar	60 kV	12 kV	PG&E	1 MW
Douglas City	60 kV	12 kV	WAPA	3 MW
Forest Glen	115 kV	12 kV	PG&E	0.5 MW
Grouse Creek	60 kV	12.5 kV	PG&E	0.25 MW
Hayfork	60 kV	12 kV	WAPA	19 MW
Hyampom	60 kV	12 kV	PG&E	2 MW
Lewiston	60 kV	12 kV	WAPA	20 MW
Mill Street	60 kV	12.5 kV	WAPA	20 MW
Trinity	230 kV	60 kV/21 kV	WAPA	60 MW

TPUD is supplied 100% of the power it needs from Western Area Power Administration (WAPA). WAPA is a power marketing administration within the US Department of Energy.

TPUD's substations are served by either 60 kV, 115kV, or 230 kV transmission lines owned and operated by Pacific Gas & Electric (PG&E) and Western Area Power Administration (WAPA). Transmission supply accounted for a significant portion of the overall outage time experienced by TPUD's consumers. In 2019, consumers on substations served by PG&E transmission lines endured 80 hours of transmission outages and in 2020, consumers experienced 36 hours of transmission outages. Consumers served by substations on WAPA transmission lines fared significantly better. In 2019, consumers experienced 19 hours of transmission outages and in 2020, consumers experienced 5 hours of transmission outages. PG&E transmission lines have a large amount of exposure and serves the smaller TPUD substations that are in more rural areas. In recent years, PG&E transmission has been severely affected by wildfires. Additional information regarding power reliability can be found in Section 4.4.

3 BASIS OF STUDY

3.1 Design Criteria

The plans presented in this study are designed to provide a guide for the orderly development of TPUD's distribution system. Planning criteria has been established to evaluate the distribution system at TPUD. The criteria include voltage and line loss levels, conductor and device loading limits, and system reliability. Other considerations include economic analysis, environmental impact, and future power supply changes. Some of the specifics of these criteria are as follows:

- The minimum voltage on the distribution system is not to be less than 118 volts on a 120-volt base under normal peak load conditions. (This assumes the source voltage will be 124 volts.)
- The overall design will be based on a balanced system, allowing for one set of voltage regulators beyond the substation.
- The loading on any conductor is not to exceed 50% of its emergency thermal loading limit.
- Single-phase lines with loading of 50 amps or more will be considered to be rebuilt to three-phase lines.
- Minimum main three-phase feeder size will be 4/0 conductor when reconductoring or building new feeder line.
- Minimum size conductor considered for use will be either 1/0 ACSR or 1/0 URD.
- System improvements will be considered in areas where excessive member outages and cable failures occur.
- Deteriorated plant replacement, addressing line that is not specifically addressed by excessive voltage drop, road projects, or loading, will be a focus to improve reliability. Line replaced under this criterion seeks to eliminate undersized wire, reduce voltage drop, decrease losses, improve system reliability, and improve safety.
- Unfinished work-in-progress projects are assumed to be completed and part of the existing system model.

3.2 References

In preparation of this five-year plan, the following documents were used as references:

- Trinity Public Utilities District System Improvement Plan – prepared by BKI Engineering, 2016
- 2012-2021 Fiscal Year Budgets – prepared by TPUD

3.3 Equipment Loading

TPUD designs the distribution system so the minimum voltage is not to exceed 118 volts on a 120-volt base under normal peak load conditions, assuming a starting voltage of 126 volts. Table 3.1 and Table 3.2 explains the loading levels used by TPUD in planning changes to the distribution system.

Table 3.1 Equipment Loading Actions

Equipment Loading Actions		
Device	Loading Level Exceeds	Action
Voltage Regulator	75%	Upgrade Device (or further analyze)
Substation Transformer	100%	Upgrade Device (or further analyze)
Line Fuses	75%	Upgrade Device (or further analyze)
	100%	Replace
Reclosers	75%	Upgrade Device (or further analyze)
	100%	Replace
Sectionalizers	75%	Upgrade Device (or further analyze)
	100%	Replace
Single-Phase Conductor	50 Amps	Consider Upgrading to Three-Phase
Primary Conductor	50% of emergency thermal loading limits	Upgrade Conductor Size or Change System Configuration

OVERHEAD CONDUCTOR THERMAL LIMITS								
12.5 kV Distribution System								
	Winter				Summer			
	Normal Demand		Emergency Demand		Normal Demand		Emergency Demand	
Overhead Conductor	Current (amps)	Power (kW)	Current (amps)	Power (kW)	Current (amps)	Power (kW)	Current (amps)	Power (kW)
#4 ACSR (#6 Cu.)	160	3,100	200	3,900	125	2,400	155	3,000
#2 ACSR (#4 Cu.)	215	4,200	270	5,300	165	3,200	210	4,100
1/0 ACSR (#2 Cu.)	280	5,500	350	6,800	215	4,200	270	5,300
T2-2 ACSR	320	6,200	400	7,800	245	4,800	305	5,900
3/0 ACSR	375	7,300	475	9,300	290	5,700	365	7,100
4/0 ACSR	430	8,400	535	10,400	330	6,400	410	8,000
T2-1/0 ACSR	430	8,400	535	10,400	330	6,400	410	8,000
336.4 MCM ACSR	665	13,000	830	16,200	510	9,900	640	12,500
397.5 MCM ACSR	740	14,400	925	18,000	570	11,100	710	13,800
477 MCM ACSR	825	16,000	1,025	19,900	630	12,200	790	15,400

Assumed conditions are as follows:

- 2) Wind velocity: 2 feet/second (1.36 mph)
- 3) Emissivity at 0.5
- 4) Normal and Emergency limits are based on maximum allowable conductor temperatures of 75° C and 100° C, respectively
- 5) Assumed balanced three-phase load at 90% power factor
- 6) T2-2 and T2-1/0 assumed characteristics thermally of 2/0 and 4/0 ACSR, respectfully

4 LOAD ANALYSIS

4.1 Purchases

In fiscal year 2020/2021, TPUD purchased 141,300 MWh from WAPA. TPUD is currently forecasting that energy purchases will stay flat over the next five years for budgeting purposes, as shown in Table 4.1. However, for this study, moderate and high growth scenarios are assumed.

Table 4.1 Energy Purchases by Supplier

Energy Purchases Actual & Forecasted (MWh)										
	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	2023/2024	2024/2025	2025/2026
WAPA	120,400	120,600	118,600	126,900	141,300	141,260	141,260	141,260	141,260	141,260
Total	120,400	120,600	118,600	126,900	141,300	141,260	141,260	141,260	141,260	141,260

A summary of the energy loss for the past five years is shown below. Energy losses are defined by subtracting the number of kilowatt-hours sold from the number of kilowatt-hours bought. As shown in Table 4.2, the five-year average system energy losses remained in the 9% range. Nationally, the average system losses for electrical utilities are 7%. TPUD’s system losses have been estimated to cost the utility approximately \$317,000 in 2020. As wholesale power costs continue to rise, it is expected that these same losses will cost the utility more in the future.

One way to decrease electrical losses is to replace older substation and distribution transformers with more efficient models. Another method to decrease electrical losses is to use larger conductor sizes to reduce the thermal losses, (Example: using 1/0 or 4/0 ACSR instead of #2 ACSR on main three-phase lines.) A reduction of 1% in losses results in annual saving of \$45,000.

Table 4.2 Historical System Losses

Historical System Losses					
Year	Energy Purchased	Energy Sold	Own Use	Losses	Losses
	(MWh)	(MWh)	(MWh)	(MWh)	(%)
2016/2017	120,423	101,035	-	10,821	8.99%
2017/2018	120,577	108,677	-	11,746	9.74%
2018/2019	118,556	109,676	-	10,901	9.19%
2019/2020	126,855	107,666	-	10,890	8.58%
2020/2021	141,260	114,245	-	12,610	8.93%
				Five Year Average	9.09%

4.3 Growth Patterns

4.3.1 Energy Sales

In the past ten years, there has been an average of a 0.16%-consumer increase per year; in the past five years, the average consumer increase per year was 0.12%. During those time periods, energy sales have increased on average 3.2% per year over ten years and increased on average 4.58% per year over five years. A summary of the member and load data for the time period of 2009-2021 is presented in Table 4.4.

In 2020, the total energy sales were 141,260 MWh. The breakdown of consumers and energy sales by consumer classification for TPUD is shown in Figures 1 and 2. A further break down can be found in Table 4.3.

Figure 1 2020 Energy Usage by Classification

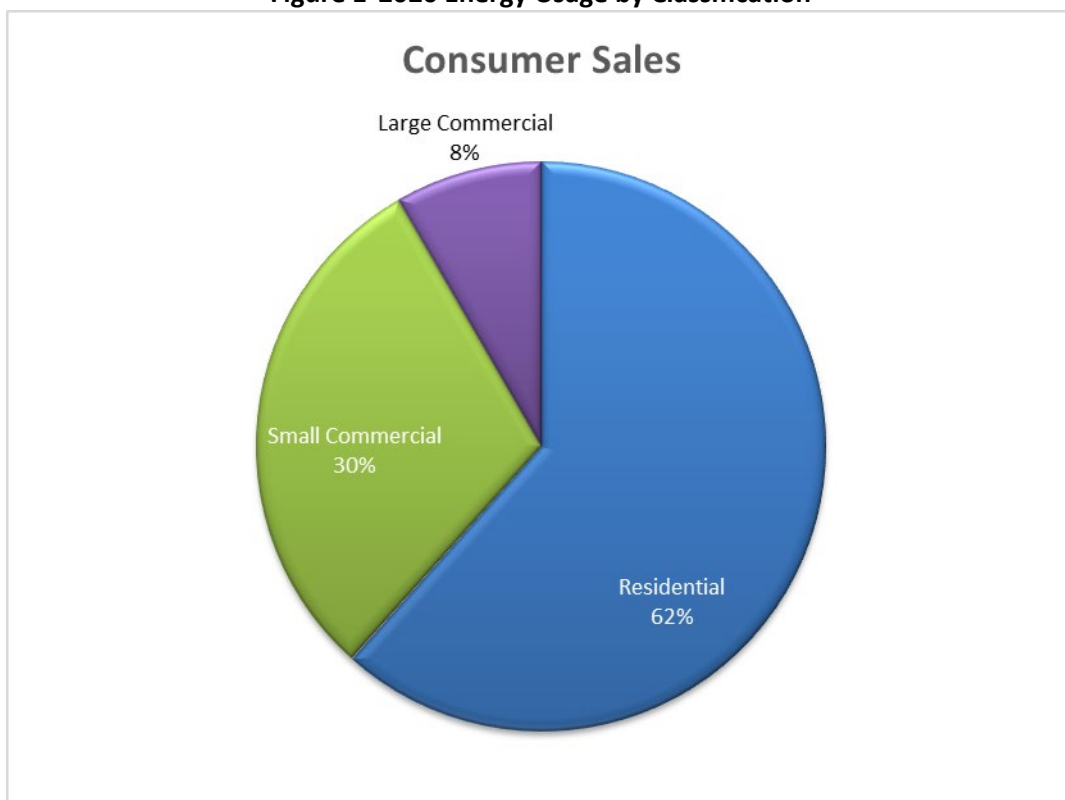
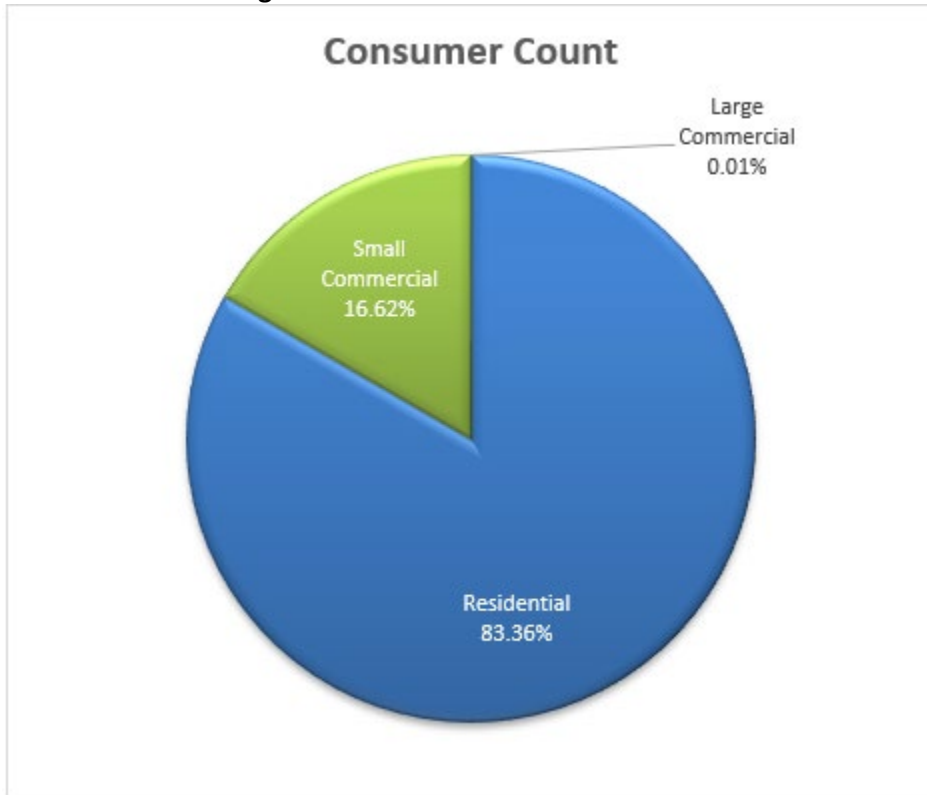


Figure 2 2020 Consumer Classification



Residential and small commercial average monthly energy usage has stayed consistent over the past five years from the average high of 1,173 kWh in 2019/2020 to the low of 1,200 kWh in 2016/2017. It is not expected that the average monthly energy usage for residential and small commercial services will increase significantly in the next five years.

Table 4.3 Monthly Energy Usage Residential and Small Commercial Classes

Monthly Energy Usage Residential and Small Commercial Classes				
	2016-2017	2017-2018	2018-2019	2019-2020
Residential	912	929	911	910
Small Commercial	2,669	2,332	2,266	2,330
Average Energy Use	1,200	1,159	1,133	1,173

Table 4.4 Historical Load Data

Historical Load Data											
Fiscal Year	Usage Growth				Losses		System Demand			Meter Growth	
	Energy Purchased	Energy Sold	Own Use	Increase in Energy Sold	Energy Loss	Loss Percent of Purchase	System Peak Demand	Increase in Peak Demand	Annual Load Factor	Average Consumer Count	Increase in Consumer Count
	(MWh)	(MWh)	(MWh)	(%)	(MWh)	(%)	(kW)	(%)	(%)		(%)
2009/2010	94,199	89,023	0	-	5,176	5.49%	18,748	-	57.36	7,119	-
2010/2011	102,918	92,717	0	4.15%	10,201	9.91%	20,483	9.25%	57.36	7,204	1.2%
2011/2012	107,747	98,246	0	5.96%	9,501	8.82%	22,244	8.60%	55.30	7,231	0.4%
2012/2013	108,184	98,047	0	-0.20%	10,137	9.37%	22,882	2.87%	53.97	7,238	0.1%
2013/2014	108,307	98,182	0	0.14%	10,125	9.35%	24,175	5.65%	51.14	7,224	-0.2%
2014/2015	105,417	94,241	0	-4.01%	11,176	10.60%	20,694	-14.40%	58.15	7,274	0.7%
2015/2016	111,856	101,035	0	7.21%	10,821	9.67%	22,066	6.63%	57.87	7,320	0.6%
2016/2017	120,423	108,677	0	7.56%	11,746	9.75%	24,274	10.01%	56.63	7,324	0.1%
2017/2018	120,577	109,676	0	0.92%	10,901	9.04%	24,286	0.05%	56.68	7,246	-1.1%
2018/2019	118,556	107,666	0	-1.83%	10,890	9.19%	24,176	-0.45%	55.98	7,246	0.0%
2019/2020	126,855	114,245	0	6.11%	12,610	9.94%	25,037	3.56%	57.84	7,261	0.2%
2020/2021	141,260	125,829	0	10.14%	15,431	10.92%	28,322	13.12%	56.94	7,322	0.8%
5 Year Average				4.58%		9.77%		5.26%	56.81%		0.01%
Growth over 5 Years				29.98%				16.68%	0.54%		-0.03%
10 year Average				3.20%		9.67%		3.56%	56.05%		0.16%
Growth over 10 Years				43.78%				27.32%	2.97%		1.26%

- Data compiled from TPUD’s financial reports
- Averages computed by taking average of past 5 or 10 years

4.3.2 Peak Demand

The peak system demand to date was 28,322 kW, which occurred in fiscal year 2020/2021. Historically, the system peak has occurred in the winter months. As shown in Table 4.4, over the past ten years the system peak on average has increased by 27.32%.

4.3.3 Load Factor

During the past five years, the average annual load factor has been 56.81%, which is consistent with the average load factor of 56.05% for the past ten years. It is expected that the load factor will remain at 56% for the next five years.

4.4 System Outages and Reliability

Power reliability varies dramatically for TPUD’s consumers depending on what substation they are served from. This is mostly due to weather events that may happen, affecting transmission and the distribution system. In 2019 and 2020, the 341 electric services served from PG&E fed substations, (Big Bar, Forest Glen, Grouse Creek, and Hyampom), experienced an average outage duration of 124 hours and 69 hours, respectively. In contrast, the 6,673 electric services served from WAPA fed substations, (Douglas City, Hayfork, Lewiston and Mill Street), experienced an average outage duration of 24 hours and 27 hours in 2019 and 2020, respectively.

The substations served by PG&E transmission are very rural; therefore, are more likely affected by the long transmission exposure. In addition, weather caused outages on the distribution system contribute to longer restoration durations due to the remote locations of the substations and their electric services.

Methods to increase reliability include adding distribution tie lines between separate circuits. Reliability tracking should also minimize the number of “unknown” outages to better address reoccurring outage issues.

Table 4.5 SAIDI Indices by Substation

Substation	Consumers	SAIDI		
		2019	2020	Two-year Average
PG&E	341	124	69	96
Big Bar	125	131	97	114
Forest Glen	26	64	32	48
Grouse Creek	6	14	24	19
Hyampom	184	131	57	94
WAPA	6673	24	27	25
Douglas City	725	26	14	20
Hayfork	1369	27	52	40
Lewiston	1631	10	11	10
Mill Street	2948	29	28	28
Total	7014	29	29	29

SAIDI: System Average Interruption Duration Index. The total sustained interruption duration for the average consumer during a calendar year.

Figure 3 2019 PG&E Substation Outage Causes

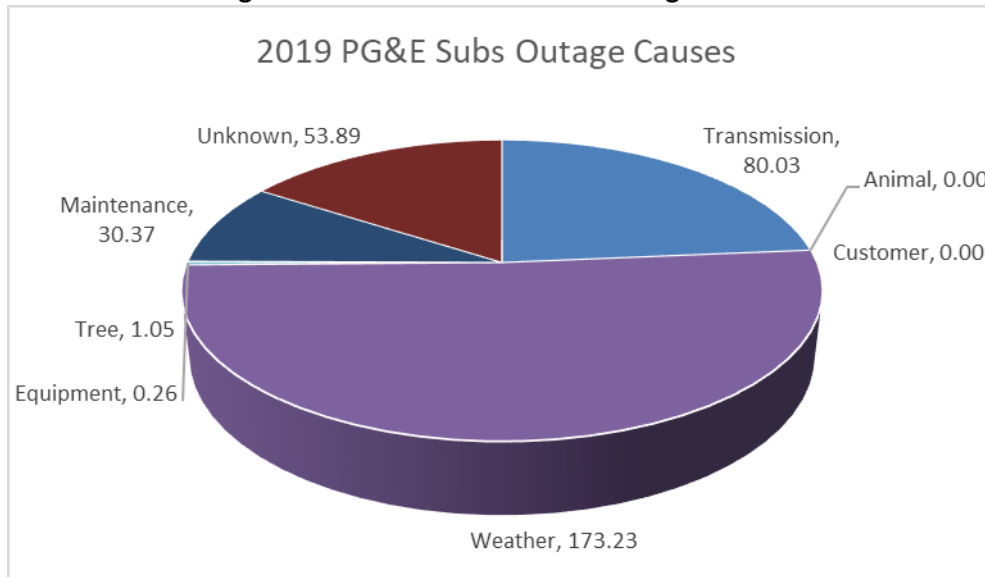


Figure 4 2019 WAPA Substation Outage Causes

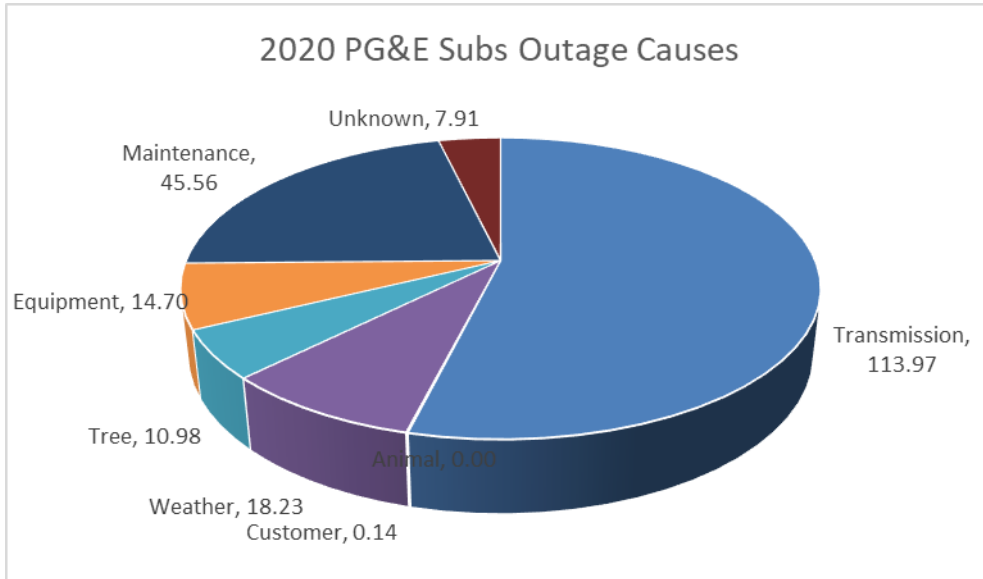
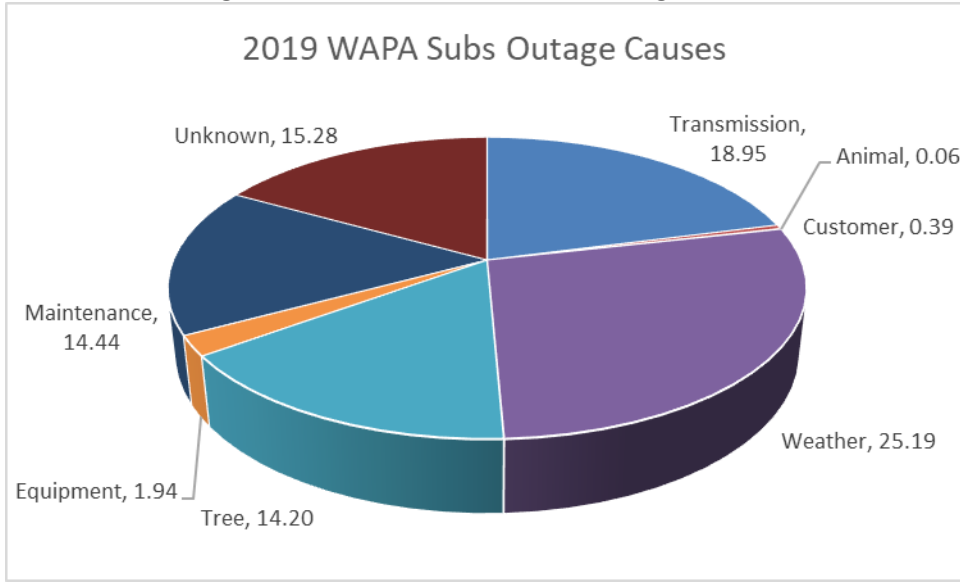
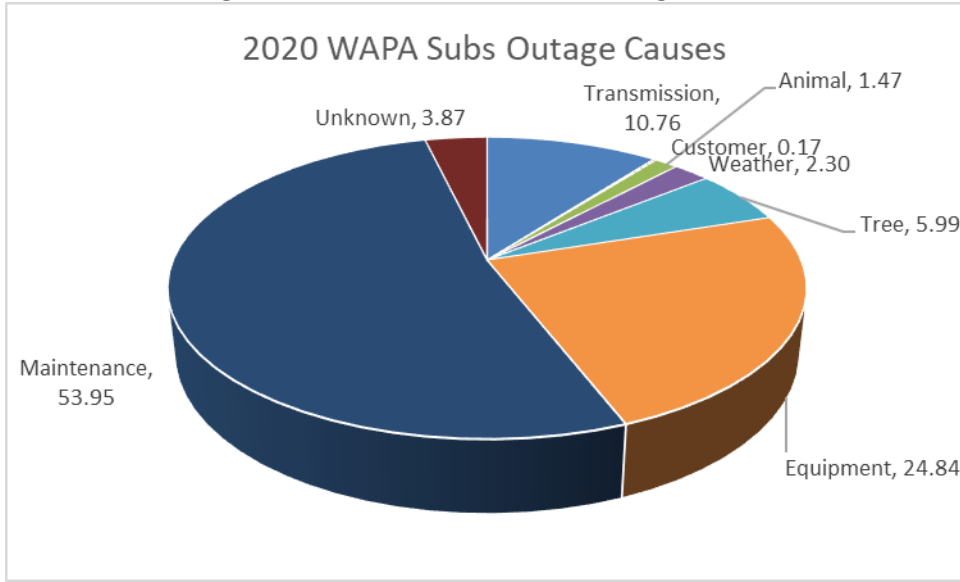


Figure 6 2020 WAPA Substation Outage Causes



TPUD deployed Aclara TWAC PLC AMI in 2019. The two-way AMI meters will allow for more advanced metering capabilities, such as automatic outage notification. The AMI deployment was completed in the 2020/2021 fiscal year. TPUD expects only to deploy new metering to approximately 100 services per year during the next five years.

5 REQUIRED CONSTRUCTION ITEMS

5.1 New and Upgraded Services

It is expected TPUD will provide service to approximately 20 new services per year for a total of 100 new services during the 2022-2026 time period. In addition, TPUD is expected to upgrade approximately 50 services each year. The expense for the new services and service upgrades will be offset by TPUD's contribution in aid policy.

5.2 Substation Transformers

In the following sections, there will be discussion to replace the existing substation transformers at various substation locations. Currently, TPUD prefers to use single-phase substation transformers. Unfortunately, there are very few transformer manufacturers that will build 60 kV and above single-phase transformers that transform voltage to 12.5 kV. The industry standard for substation transformers are now three-phase transformers with the smallest size available typically a 5 MVA. Many transformer manufacturers will either refuse to build transformers smaller than a three-phase 5 MVA or will charge more for smaller single-phase substation transformers.

While a few transformer manufacturers, such as Virginia Transformers, will still build a 60 kV/12.5 KV single-phase transformer, TPUD may choose to request the single-phase substation transformers rebuilt with various vendors, such as Jordan Transformers, T&R Electric or Solomon Corporation. The cost to purchase a refurbished unit will be significantly less than purchasing new. Do note, all estimated costs listed for substation transformers are for new three-phase units.

5.3 Big Bar Substation

The distribution system served by the Big Bar Substation does not require any specific line replacement or upgrade to serve the existing load. Big Bar Substation is not expected to have much load growth in the next five years. While the Big Bar Substation does experience a significant duration of power outages, the outages are mainly due to transmission outages from PG&E.

The Big Bar Substation is currently comprised of three single-phase substation transformers sized at 250 kVA, 333 kVA, and 333kVA with three single-phase regulators sized at 200 amps each. The transformers in the Big Bar Substation are 1960 vintage and should be either rebuilt or exchanged for a new three-phase 5 MVA transformer. If the single-phase transformers are changed to a new three-phase transformer, the foundation for the transformer will most likely need to be expanded. The estimated cost to expand the substation foundation and change the substation transformers to a three-phase 5 MVA transformer is \$350,000. This project is identified as Project BB-1.

In addition to Project BB-1, Project BB-2 is the replacement of the high side structure of the Big Bar Substation. The high side structure of the Big Bar Substation is currently a wooden structure. The wood structure is subjected to rot, flashover, and potential wildfires. The cost to replace the high side substation structure with steel construction is estimated at \$200,000.

5.4 Douglas City Substation

The Douglas City Substation currently serves approximately 1,630 electric services. The substation area is expected to grow approximately 2% annually for the next five years. Even with the planned growth, there are no distribution line projects planned for this substation area.

The Douglas City Substation is comprised of three single-phase 1 MW transformers and three single-phase 200-amp regulators. The substation equipment is approximately 15-20 years in age and in good condition. The Douglas City Substation can provide contingency electric supply to Lewiston and Mill Street Substations.

When Douglas City Substation provides contingency service to Lewiston Substation Circuit 1101, low voltage can occur and potentially a thermal overload. A lower priority project would be to upgrade Douglas City Substation Circuit 1101 for 3.5 miles from three-phase #2 ACSR to three-phase 4/0 ACSR. This project, Project DC-1, is estimated to cost \$1,790,000.

5.5 Forest Glen Substation

The Forest Glen Substation serves under 30 services, with most of them idle due to wildfires in the recent years. There is no expectation that electric load will grow in the next five years.

The transformer in the Forest Glen Substation is approaching the end of its useful life at 53 years old. However, until a clearer picture of whether electric load will return, the recommendation is to not replace the substation transformer immediately. If the load was to return during the 2022-2026 time period, the estimated cost to replace the transformer is \$300,000. TPUD may have a suitable three-phase pad mount transformer already stored in inventory. This project is known as Project FG-1.

5.6 Grouse Creek Substation

The Grouse Creek Substation serves a handful of permanent services with a single-phase 250 kVA transformer. There is no expectation that electric load will grow in the next five years. There are no distribution line projects planned for this substation area.

The single-phase transformer in the Grouse Creek Substation is approaching the end of its useful life at 56 years old. By the end of the five-year period, the transformer will be over 60 years old. Oil testing has not shown signs of deterioration; however, plans should be made to replace this transformer unit. Project GC-1, the replacement of a 60 KV/12.5 KV 333 kVA transformer, is expected to cost \$120,000.

In addition, the substation is currently of wooden frame construction. As wood structures are subjected to rot, flashover, and potential wildfires, it is recommended to rebuild the substation in steel construction. The rebuilding of the Grouse Creek Substation, Project GC-2, is expected to cost \$200,000.

5.7 Hayfork Substation

The Hayfork Substation is a dual transformer substation, with both a 7 MVA and 12 MVA three-phase substation transformer inside. There are three circuits that serve the electric load, with Circuit 1201 being the heaviest loaded at 2.2 MW. The Hayfork Substation serves approximately 20% of TPUD's consumers.

Currently, low voltages issues exist on Circuit 1201, which will only get worse as the Hayfork Substation continues to see 2% annual load growth. With the expected growth, the existing conductor will be thermally overloaded by the end of 2026.

Project HF-1 is the rebuilding of Circuit 1201 from #2 ACSR to 4/0 ACSR from the Hayfork Substation for approximately 1.2 miles. This project is estimated to cost \$600,000.

Circuit 1202 and 1203 are also expected to see 2% annual growth. These circuits are currently lighter loaded than Circuit 1201. While these circuits should not see thermal or power quality issues during the next five years, it is advisable to consider replacing the first mile of Circuit 1202 out of the substation with 397 AAC. This project, Project HF-2, is estimated to cost \$1,480,000.

The option does exist to extend 14 miles of three-phase 4/0 AL cable from Hayfork Substation Circuit 1203 to the Forest Glen Substation area. This project, Project HF-3, is expected to cost \$3,500,000. The three-phase extension also allows for the possibility to serve the Trinity Pines area and other electrical loads.

5.8 Hyampom Substation

The Hyampom Substation is comprised of three single-phase 667 kVA transformers. Oil testing indicated significant degrading to the transformers leading to the increase probability of the transformers malfunctioning. As the Hyampom Substation cannot be back fed by a neighboring substation, an outage due to the Hyampom Substation transformers failing will lead to a prolonged outage for the 185 electric services on this substation.

The estimated cost to replace the existing transformers with a 5 MVA three-phase transformer is \$450,000; including foundation modifications and new 219-amp regulators. This is known as Project HY-1.

Minor growth of 1% annual is expected to occur on the Hyampom Substation. With the projected growth, there are no distribution line projects planned for this substation area.

The electric services on the Hyampom Substation area experienced an average of 131 hours of outage duration in 2019 and an average of 57 outage hours in 2020. The leading cause of the outages is due to transmission outages from PG&E. An optional transmission project to increase the reliability to the Hyampom Substation area, Project HY-2, is to extend 60 kV line approximately 20 miles from Hayfork Substation. The cost of the transmission line extension is estimated at \$4 million per mile, due to the terrain and right-of-way acquisition.

5.9 Lewiston Substation

The Lewiston Substation is a double-ended substation with each end comprising of three 3,333 kVA single-phase transformers. The Lewiston Substation can provide contingency power supply to the Douglas City Substation. Lewiston Substation currently serves approximately 1,630 electric services.

During a contingency situation, when Lewiston Substation is providing electric service to Douglas City Substation load, there will be significant voltage drop issues that cannot all be addressed with additional distribution regulation. It is recommended that it be the long-term goal to extend three-phase 4/0 AL or 4/0 ACSR to Douglas City Circuit 1101 at Switch 3143. This project, Project LE-1, is approximately 8.5 miles of three-phase #2 ACSR that would need to be rebuilt to 397 AAC at an estimated cost of \$3,590,000.

5.10 Mill Street Substation

The Mill Street Substation is similar in construction to the Lewiston Substation, with three 3,333 kVA transformers setup in two separated substation bays. Each substation bay has three 668-amp single-phase regulators. TPUD's industrial consumer is located on Circuit 1102 and this circuit is expected to see 2% annual growth over the next five years.

Multiple different distribution line projects have been identified for this substation area. The projects are due to load growth in the area.

Recommended on the Mill Street Substation area is the rebuilding of three-phase #2 ACSR to three-phase 4/0 on Circuit 1102 from Fuse 1102 to Pole 10929 for approximately 3.5 miles. This project, Project MS-1, is needed to address low voltage and potential thermal overloading issues. The cost estimate of this project is \$1,750,000.

It is also recommended as a project to rebuild from three-phase #2 ACSR to three-phase 397 AAC on Circuit 1103 from the substation for approximately 1 mile. This project, Project MS-2, is needed to address low voltage and thermal overloading issues. The cost estimate of this project is \$511,000.

Another identified project, Project MS-3, is the rebuilding of three-phase #2 ACSR to three-phase 397 AAC on Circuit 1106 from the substation for approximately 1.4 miles. In addition, two sets of distribution line regulators are recommended to address low voltage issues. The cost estimate of this project is \$715,000.

Lastly, it is highly recommended to rebuild three-phase #2 ACSR to three-phase 4/0 ACSR on Circuit 1107 from the substation for approximately 1 mile. Circuit 1107 has various segments of the distribution system ranging between #2 ACSR to 4/0 ACSR for the first three miles from the substation. This project, Project MS-4, is needed to address low voltage issues. The cost estimate of this project is \$500,000.

In addition to the distribution projects identified in this section, it is also recommended that the recloser controls located in the Mill Street Substation be upgraded from the Cooper Form C to Cooper Form 7 controllers. With this change, it is also recommended that any oil filled reclosers within the substation be changed to vacuum reclosers. Each circuit recloser bank replacement with updated controls is expected to cost \$87,500. In this project, Project MS-5, it is assumed four (4) banks of reclosers are to be changed out for a total estimated cost of \$350,000.

5.11 Trinity Substation

The Trinity Substation is owned and operated by WAPA. The substation is comprised of two 30 MW three-phase three-winding transformers. The 230kV/60 kV windings of the Trinity Substation leave the Trinity Substation as a transmission circuit to the Lewiston Substation, Douglas City Substation, and Mill Street Substation. The other transformer winding is 21 KV and is transformed further outside the substation at a 21kV/12 kV 2.5 MW pad mount transformer. This distribution circuit then continues north around Trinity Lake towards the Trinity Center Airport. In addition, the 21 kV circuit from the Trinity Substation extends north approximately 11 miles to where there is another 21kV/12 kV 2.5 MW pad mount transformer that can be tied into the north Trinity circuit for redundancy. No distribution or transmission projects have been identified for the Trinity Substation area.

5.12 Miscellaneous Replacements & Additions

5.12.1 Underground Cable Replacement

TPUD should plan to replace one mile of three-phase underground cable on an annual basis due to the eroding of the concentric neutral from cable installed in the 1970-1980s. If the conductor to be replaced is part of the circuit backbone, it is strongly encouraged the cable installed be upgraded to 4/0 AL. The estimated cost annually is \$320,000. Environmental planning costs are not included in this estimate.

5.12.2 Pole Replacements

With the existing pole testing process, TPUD should expect to change out approximately 225 poles per year. Annually, this would be a cost of approximately \$450,000 per year.

5.12.3 Metering Replacements

TPUD finished the deployment of Aclara TWAC PLC AMI system in the fiscal year 2020/2021. While all meters have been changed out, TPUD will still expect to add or change out approximately 100 meters annually. The cost of the metering on an annual basis is estimated at \$20,000 per year.

5.12.4 Transformer Installations

While there still are a few new electric services occurring annually, TPUD's load growth is mainly due to existing services upgrading in size. Between the new services and upgrading of existing services, along with normal equipment replacement, TPUD will need to budget for approximately \$126,000 in distribution transformer purchases and installation annually.

5.12.5 Line Regulators

TPUD should plan to add three (3) line regulators annually to assist with continual growth on the distribution system. The cost of the line regulators and installation is estimated at \$60,000 annually.

5.12.6 Line Reclosers

TPUD should plan to add one (1) three-phase bank of line reclosers annually to continue to sectionalize the distribution system to help with reliability improvement. The estimated cost of the three-phase line reclosers bank and installation is estimated at \$60,000 annually.

6 COST BY CODES

The following section includes detailed information on the projects planned for the 2022-2026 time period.

Table 6.1 Substation and Transmission Changes

SUBSTATION AND TRANSMISSION CHANGES					
Project Code	Priority	Substation	Project Description	Estimated Cost	
BB-1	High	Big Bar	Replacement of 250/333/333 kVA transformers with 5 MVA transformer	\$ 350,000	
BB-2	High	Big Bar	Replacement of wooden substation structure	\$ 200,000	
FG-1	High	Forest Glen	Replacement of 560 kVA three-phase transformer	\$ 300,000	
GC-1	High	Grouse Creek	Replacement of 60 kV/12.5 kV 250 kVA three-phase transformer	\$ 120,000	
GC-2	High	Grouse Creek	Replacement of wooden substation structure	\$ 200,000	
HY-1	High	Hyampom	Replacement of 677/677/677 kVa transformers and 219 A regulators	\$ 450,000	
MS-5	High	Mill Street	Replacement of 4 oil-filled reclosers banks with vaccum recloser with Form 7 controls	\$ 350,000	
HY-2	Low	Hyampom	Extension of 60 kV Transmission from Hayfork Substation to Hyampom Substation	\$ 80,000,000	
				Total	\$ 81,970,000
				High	\$ 1,970,000
				Low	\$ 80,000,000
				Total	\$ 81,970,000

Distribution Line Changes

DISTRIBUTION LINE CHANGES											
Project Code	Priority	Sub/Ckt	Existing Line			New Line			Miles	Estimated Cost	
			Phase	OH UG	Conductor	OH UG	Phase(s)	Conductor			
HF-1	High	Hayfork 1201	3	OH	#2 ACSR	OH	3	4/0 ACSR	1.20	\$ 600,000	
LE-1	Low	Lewiston 1101	3	OH	#2 ACSR	OH	3	397 AAC	8.50	\$ 3,590,000	
DC-1	Low	Douglas City 1101	3	OH	#2 ACSR	OH	3	397 AAC	3.50	\$ 1,790,000	
HF-3	Low	Hayfork 1203	-	-	-	OH	3	4/0 ACSR	14.00	\$ 3,500,000	
HF-2	Low	Hayfork 1202	3	OH	#2 ACSR	OH	3	397 AAC	2.90	\$ 1,480,000	
MS-1	High	Mill Street 1102	3	OH	#2 ACSR	OH	3	4/0 ACSR	3.50	\$ 1,750,000	
MS-2	High	Mill Street 1103	3	OH	#2 ACSR	OH	3	397 AAC	1.00	\$ 511,000	
MS-3	High	Mill Street 1106	3	OH	#2 ACSR	OH	3	397 AAC	1.40	\$ 715,000	
MS-4	High	Mill Street 1107	3	OH	#2 ACSR	OH	3	4/0 ACSR	1.00	\$ 500,000	
									Total	37.0	\$ 14,436,000
									High	8.1	\$ 4,076,000
									Low	28.9	\$ 10,360,000
									Total	37.0	\$ 14,436,000

Table 6.3 Miscellaneous Line Additions and Replacements

MISCELLANEOUS LINE ADDITIONS AND REPLACEMENTS			
Description	Duration	Quantity	Annual Cost
Underground Cable	Annually	1 mile	\$ 320,000
Poles	Annually	225	\$ 450,000
Metering	Annually	100	\$ 20,000
Transformers	Annually	100	\$ 126,000
Regulators	Annually	3 (1φ)	\$ 60,000
Reclosers	Annually	1 (3φ)	\$ 60,000
Total			\$ 1,036,000

Table 6.4 Summary of Costs Breakdown

2022-2026 System Improvement Infrastructure Costs	
High Priority	
Substation Projects	\$ 1,970,000
Distribution Line Projects	\$ 4,076,000
Annual Replacements	\$ 1,036,000
High Priority Projects & Replacements Total	\$ 7,082,000
Low Priority	
Substation Projects	\$ -
Distribution Line Projects	\$ 10,360,000
Low Priority Projects Total	\$ 10,360,000
High & Low Priority Projects & Replacements	\$ 17,442,000
Transmission Projects	\$ 80,000,000
All Identified Projects & Replacements	\$ 97,442,000