Pacific Gas and Electric Company

California North Coast Offshore Wind Studies

Interconnection Feasibility Study Report

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Disclaimer

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About the Schatz Energy Research Center

The Schatz Energy Research Center at Humboldt State University advances clean and renewable energy. Our projects aim to reduce climate change and pollution while increasing energy access and resilience.

Our work is collaborative and multidisciplinary, and we are grateful to the many partners who together make our efforts possible.

Learn more about our work at schatzcenter.org

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Table of Contents

Tables:

Executive Summary

Pacific Gas and Electric Company (PG&E) is pleased to support Schatz Energy Research Center (Schatz Center) to conduct an informational feasibility study for interconnecting offshore wind generation near Humboldt Bay. Performing this informational feasibility study is in response to the Bureau of Ocean Energy Management's request to better understand the feasibility of interconnecting potential offshore wind generation, and the potential electric grid impacts. The study is funded under a cooperative agreement with the Bureau of Ocean Energy Management (BOEM).

The Schatz Energy Research Center of Humboldt State University requested PG&E to perform a study to evaluate impacts of interconnecting three scales of wind farms to the PG&E electric transmission system.

Below are the wind farm scales that will be studied in years 2029. The wind farms are to be assessed individually:

- Option 1 – 48 MW, consisting of four 12 MW turbines
- Option 2 – 144 MW, consisting of twelve 12 MW turbines

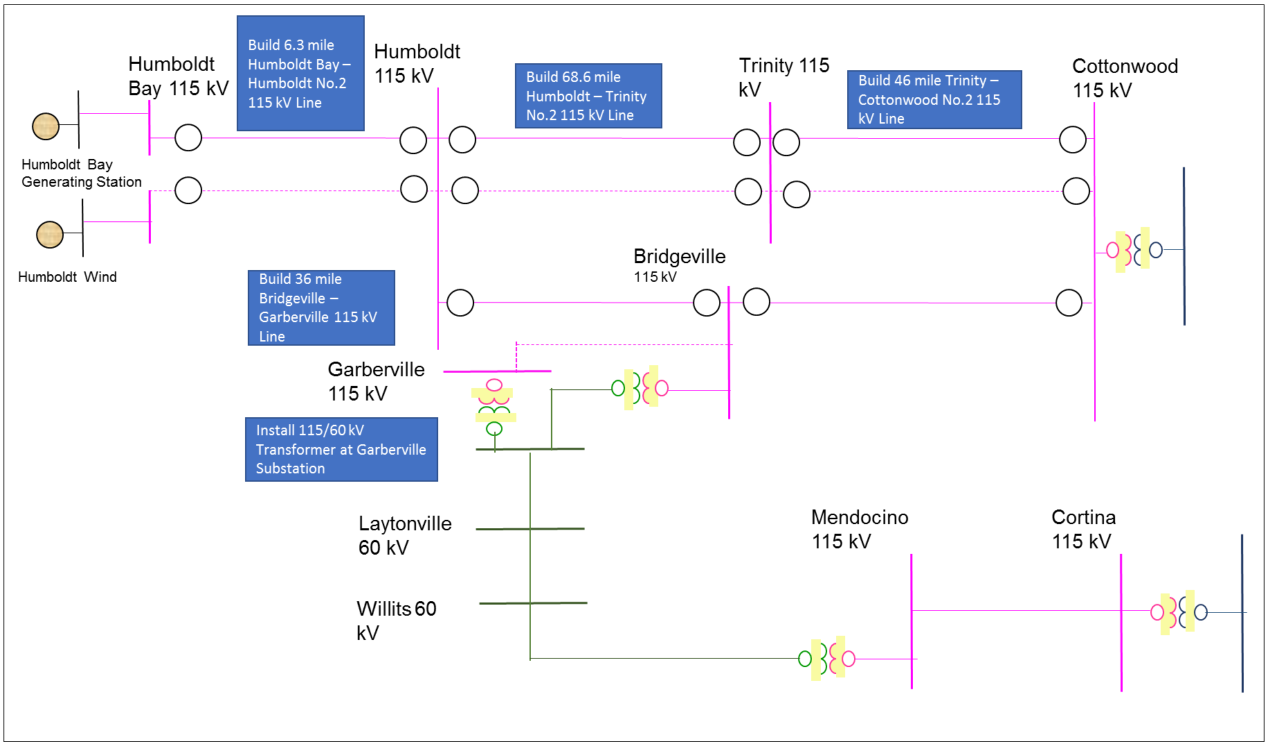
The above wind farm projects will assume interconnection at Humboldt Bay 115 kV Substation.

- Option 3 – 1,836 MW, consisting of one hundred fifty-three 12 MW turbines

The entire 1,836 MW is to be interconnected at new 500 kV Substation by Humboldt Bay.

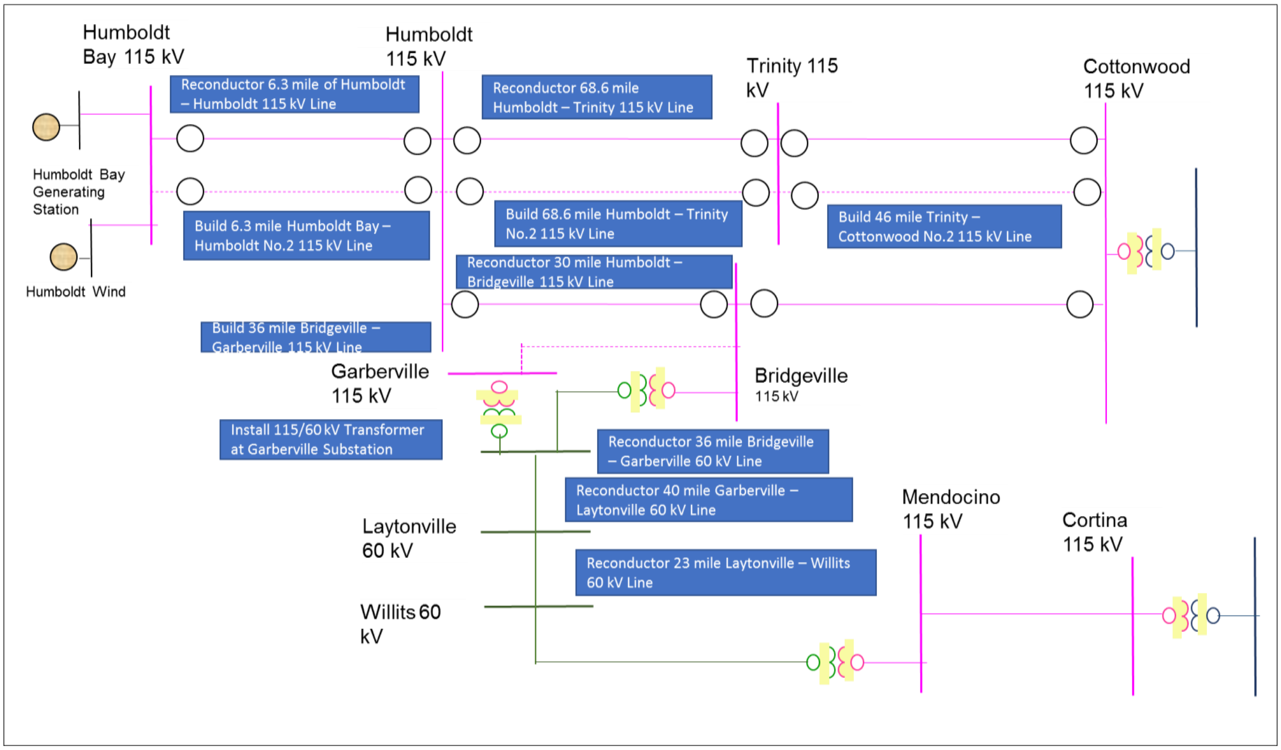
Considering the Humboldt area has a relatively less densely populated load center with an adequate amount of internal generation, the system is currently designed for small margin to import and export electric power. The import and export capability in this area is very weak, therefore, to interconnect a large amount of generation in this area would require robust alternatives. Various alternatives will be considered to address exports to large load areas off the coast of California as well as alternatives leading to strong 500 kV and 230 kV Transmission pathways. All alternatives will lead power to the CAISO controlled transmission grid and eventually flow to large load centers that will benefit from the diverse mix of generating resources.

Option 1 – 48 MW, consisting of four 12 MW turbines
This option considered 48 MW's connected at Humboldt Bay 115 kV Substation. Based on the contingency analysis, study results show normal system overloads and overloads caused by single contingencies. Analysis performed show that when a loss of a 115 kV transmission line occurred the remainder 115 kV lines overload due to the excess power flow. The current system configuration and capacity would not be able to support 48 MW's connected to the Humboldt system in a heavy summer scenario with Humboldt Generating Station operating at close to or full output. It is recommended to build 115 kV lines to alleviate congestion on the Humboldt 115 kV Transmission grid. Potential upgrades may cost between $365M to $730M.



Alternative	OPTION 1 to interconnect 48 MW's in Humboldt Area Facility	Cost Estimate
Alt 1: Status Quo		$0
Alt 2: Build New 115 kV Transmission Lines	Build new 6.3 mile Humboldt Bay - Humboldt No. 2 115 kV Line	$14M
	Build new 68.58 mile Humboldt - Trinity No. 2 115 kV Line	$154M
	Build new 46.28 mile Trinity - Cottonwood No. 2 115 kV Line	$104M
	Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation	$12M
	Build a new 36 mile Bridgeville - Garberville No. 2 115 kV Line	$81M
	Total	$365M - $730M

Option 2 – 144 MW, consisting of twelve 12 MW turbines
This option considered 144 MW's connected at Humboldt Bay 115 kV Substation. Based on the contingency analysis study, results show normal system overloads and overloads caused by single contingencies. Analysis performed showed that when a 115 kV transmission line loss occurred the remaining 115 kV lines overload due to the excess power flow. The current system configuration and capacity would not be able to support 144 MW's connected to the Humboldt system in a heavy summer scenario with Humboldt Generating Station operating at close to or full output. It is recommended to build 115 kV lines to alleviate congestion on the Humboldt 115 kV Transmission grid. It is also recommended to interconnect to Humboldt 115 kV Substation to offload costs and avoid reconductoring and building a new line to Humboldt Bay 115 kV Substation. Potential upgrades may cost between $669M to $1.34B.



OPTION 2 to interconnect 144 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt 1: Status Quo		$0
Alt: 2 Reconductor and build new 115 kV and 60 kV Lines	Reconductor 6.3 miles of Humboldt Bay - Humboldt 115 kV Line	$14M
	Reconductor 30.3 miles of Humboldt - Bridgeville 115 kV Line	$68M
	Reconductor 68.58 mile of Humboldt - Trinity 115 kV Line	$50M
	Reconductor 36 mile of Bridgeville - Garberville 60 kV Line	$30M
	Reconductor 40 miles of Garberville - Laytonville 60 kV Line	$90M
	Reconductor 23 miles of Laytonville - Willits 60 kV Line	$52M
	Build new 6.3 mile Humboldt Bay - Humboldt No. 2 115 kV Line	$14M
	Build new 68.58 mile Humboldt - Trinity No. 2 115 kV Line	$154.2M
	Build new 46.28 mile Trinity - Cottonwood No. 2 115 kV Line	$104.25M
	Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation	$12M
	Build a new 36 mile Bridgeville - Garberville No. 2 115 kV Line	$81M
	Total	**$669M - $1.34B**

Option 3 – 1,836 MW, consisting of one hundred fifty-three 12 MW turbines
As explained above, considering that the Humboldt transmission system has no 500 kV facilities and has limited importing and exporting capabilities to allow interconnection of such large amount of new generation, three distinct alternatives to connect to the existing 500 kV system were evaluated under this option. The alternatives considered to interconnect the entire 1,836 MW are:

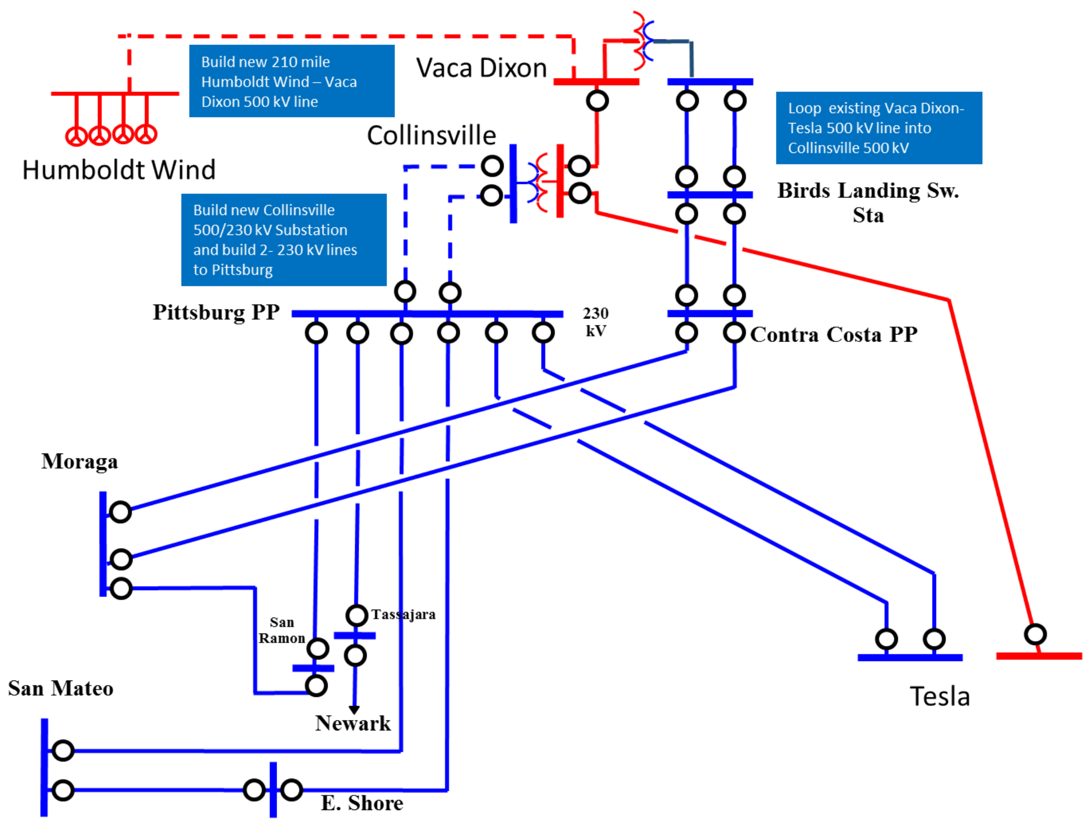
Alternative 1
This alternative consists of an interconnection of 1,836 MW's from the Humboldt shore to Round Mountain 500 kV Substation. The Round Mountain 500 kV Substation is part of a WECC

path 66 connection. In depth studies will need to be performed and coordinated between the CAISO, WECC and Affected Parties. The studies performed indicated with COI fully scheduled there is not enough capacity to interconnect 1,836 MW's. It is recommended to build new 500 kV lines from Round Mountain 500 kV Substation down to the major PG&E load center. The load center is served from Vaca Dixon and Tesla 500 kV substations. Contingency analysis was performed for governor power flow and no substantial issues were identified for the additional 500 kV path. It is also recommended that many more robust studies occur to capture voltage and transient stability if it is decided this alternative is viable. Potential upgrades may cost between $1.4B to $2.8B.

OPTION 3 to interconnect 1836 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt: 1 Build 500 kV Line from Humboldt area to Round Mountain 500 kV Substation	Build new 120 mile Humboldt Wind - Round Mountain 500 KV Line	$480M
	Build new 89 mile Round Mountain - Table Mountain 500 KV Line	$360M
	Build new 83 mile Table Mountain - Vaca Dixon 500 kV Line	$336M
	Build new 57 mile Vaca Dixon - Tesla 500 kV Line	$228M
	Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line	$5M
	Total	**$1.4B - $2.8B**

Alternative 2

This alternative connects the Humboldt offshore wind to the Vaca Dixon 500 kV Substation. By going directly to the Vaca Dixon substation and a direct path into the Bay Area with the Collinsville Project, the effects on COI are limited and no substantial issues were identified in governor power flow analysis. The additional scope of work to implement the Collinsville Project would bring in another 500 kV source into the bay area and serve bay area demand. The Collinsville connection terminates at Pittsburg Substation which has many robust outlets. Transmission lines connect to Potrero (via TBC) and serves the SF area. A connection to San Mateo is also available and serves the Peninsula. The Tri Valley, Fremont and San Jose area also connected to Pittsburg. The Oakland area is also served by Pittsburg. Lastly a major connection to Tesla is also available to import or export any excess power to be distributed throughout PG&E greater transmission system. Potential upgrades may cost between $1.4B to $2.8B.

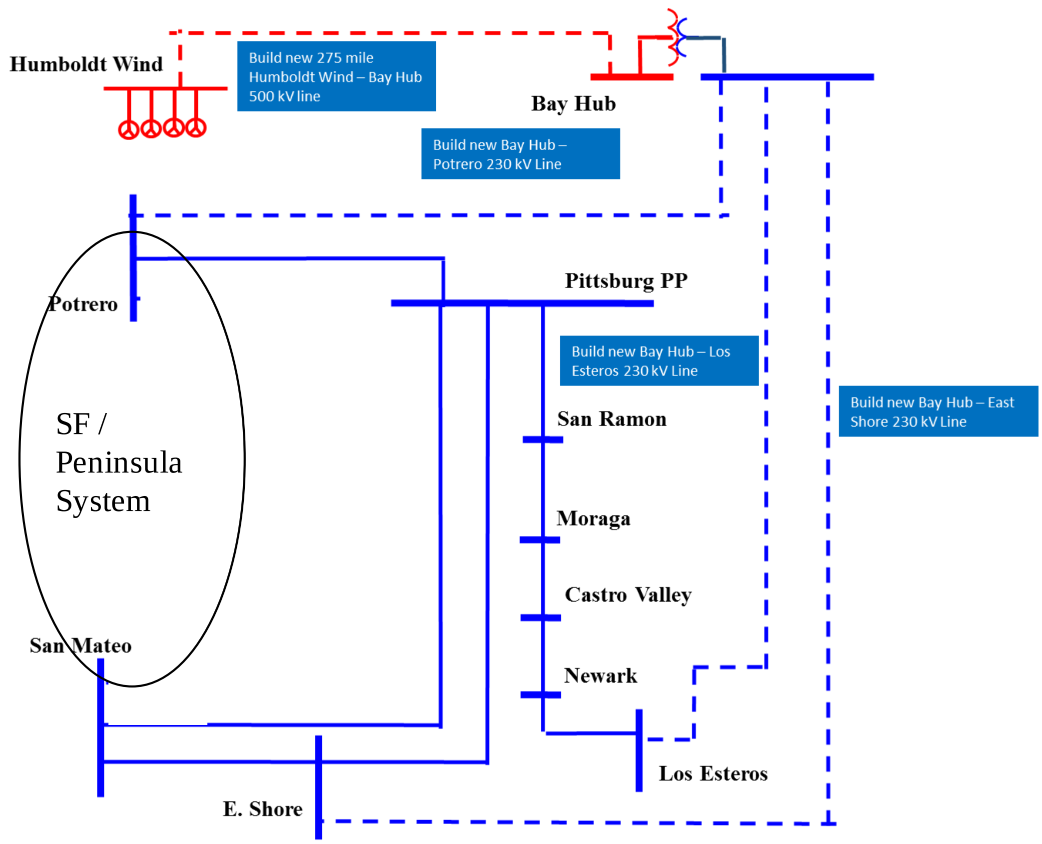


OPTION 3 to interconnect 1836 MW's in Humboldt Area		
Alternative	Facility	Cost Estimate
Alt 2: Build 500 kV Line from Humboldt area to Vaca Dixon	Build new 210 mile Humboldt Wind - Vaca Dixon 500 kV Line	$840M
	Build new Collinsville 500 kV Substation	$500M
	Loop Vaca Dixon-Tesla 500 kV line into new Collinsville Substation	
	Reconductor 25 miles of Vaca Dixon-Collinsville 500 kV Line	
	Install 500/230 kV transformer at new station	
	Construct two, 5.3-mile underground 230 kV lines over to Pittsburg P.P. Substation	
	Install voltage support as required at various locations with the Bay Area	
	Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line	$20M
	Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line	$5M
	Reconductor 3 miles of Cayetano - North Dublin 230 kV Line	$5M

	Reconductor 9 miles of Newark D - NRS 400 115 kV Line	$20M
	Reconductor 8.5 miles of Pittsburg - Clayton 115 kV Line	$13M
	Total	**$1.4B - $2.8B**

Alternative 3

This alternative involves building a 500 kV substation within the Bay Area. This 500 kV substation would have three 230 kV lines that export power to Potrero, Los Esteros, and East Shore 230 kV substations. This alternative does not interconnect to the 500 kV Bulk System. All generation is in turn subscribed within the Bay Area. Depending on the allocation of MW's per designated substation the alternatives could include many local upgrades to none at all. In the capacity section of the report more details are provided. It is recommended that the 230 kV lines coming out of the BayHub Substation be DC controllable. Potential upgrades may cost between $3.5B to $5.8B.



OPTION 3 to interconnect 1836 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt 3: Build 500 kV Line from Humboldt area to Bay Area	Build new 275 mile Humboldt Wind - BayHub 500 kV Line	$2.75B
	Build new Bay Hub 500/230 kV Substation	$700M
	Build 3-230 kV HVDC subsea cables	
	1) Bay Hub - Potrero No. 1 230 kV Line	
	2) Bay Hub - E. Shore No. 1 230 kV Line	
	3) Bay Hub - Los Esteros No. 1 230 kV Line	
	Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line	$20M
	Total	**$3.5B - $5.8B**

Introduction

The Humboldt County Offshore Wind Feasibility Analysis is comprised of three different options and generations sizes being studied. All options will be studied in year 2029.

The first option includes an interconnection of wind generation plant with a total rated output of 48 MW to Pacific Gas and Electric's (PG&E's) Humboldt Bay 115 kV Substation which is located in Humboldt County, CA. The project was modelled with a total installed capacity of 55.57 MVA to meet FERC Order 827 which FERC addresses Reactive Power Requirements for Non-Synchronous Generators and FERC Order 842 which addresses interconnected generators to provide frequency response.

The second option includes an interconnection of wind generation plant with a total rated output of 144 MW to Pacific Gas and Electric's (PG&E's) Humboldt Bay 115 kV Substation which is located in Humboldt County, CA. The project was modelled with a total installed capacity of 165.71 MVA to meet FERC Order 827 and FERC Order 842.

The third option includes an interconnection of wind generation plant with a total rated output of 1836 MW to Pacific Gas and Electric's (PG&E's) electric grid. Per the Schatz Research Energy team various routes were assessed to export power to the bulk transmission system. The three alternatives considered include 1) a route to the east 2) a route to the southeast 3) a route directly to the bay area load centers. The project was modelled with a total installed capacity of 2105.18 MVA to meet FERC Order 827 and FERC Order 842.

For the above high level scope projects to be interconnected high level transmission upgrades will be necessary. Alternatives above consider contingency analysis and scope of alternatives have been increased to mitigate potential normal system (N-0) and single contingency (N-1) outages. All alternatives studied are to be used for informational purposes. Within this Informational Feasibility Study, PG&E may propose variations, additions, or other alternatives and Point of Interconnections (POIs) that may be better suited for interconnecting Project Options in the recommendations section of the report.

The study will assess the units at full capacity deliverable status with a current snapshot of the system for heavy summer and spring off peak scenarios. The basecases utilized are used for reliability studies and developed through the CAISO Transmission Planning Process (TPP). Generation dispatch is again based on TPP assumptions and does not reflect the optimal dispatch based on economics, as price per MW by unit is not available for this study. Also within this study no curtailments are assumed for a status quo basecase which includes generation options modelled and no contingency performed. Curtailments were also not addressed for any single contingency. Solutions or mitigations are suggested for potential violations. Congestion management however is observed for P6 contingencies which includes a single contingency to occur, with time in between for the system to adjust, and then another contingency occurs.

Please also note the various generator options are not modelled at collector station and collector branch levels as transient stability is not in the scope of this study. The generation total amount is modeled at the assumed POI bus.

The Informational Study will identify:

- Transmission system impacts caused solely by the addition of the Project
- System reinforcements necessary to mitigate any adverse impacts of the project under various system conditions; and
- Facilities required for system reinforcements with a non-binding good faith estimate of cost of responsibility.

Study Assumptions

Load Assumptions

PG&E has prepared a System Bulk basecase that focusses primarily on the Extra High Voltage (EHV) System. The System base cases model the WECC full-loop (interconnected) system with a load forecast that assumes a 1-in-5-year high ambient temperature adverse weather condition for the collective PG&E system.

Historically, PG&E has been a “summer peaking” system. There are pockets within PG&E that can experience higher demand loading in periods other than the summer months (for example, Humboldt and the coastal areas of the North Coast, North Bay, San Francisco, Peninsula and Central Coast often peak during the winter months). In this study since we are observing the overall effects to the entire PG&E system a summer peak scenario was chosen to study. This scenario includes heavy North to South flows on COI a 500 kV path that interconnects Oregon and California. In addition to Summer Peak conditions, other potentially limiting system conditions studied include Spring Off-Peak[1] conditions, with much lower system load than in the corresponding Summer Peak case. The table below reflects the time of year captured in the studies:

Table 1 Scenario Time Summary

Seasons	Load Periods
Summer (Jun 1 – Aug 31)	Peak (5pm to 7pm, weekdays)

For Year 10 (2029) basecases, Reactive Load forecasts are based on a general power factor assumption (0.97 lagging for summer peak cases and 0.99 leading power factor for off-peak cases) based on historical and expected power factor performance.

Load forecasts for the system cases are based on a 1-in-5-year adverse weather assumption based on ambient temperature; the resulting yearly forecasts for each Planning Area are shown in the table below. Each of the columns of represents a single Summer Peak case and each row represents the division Load in MW or Alternative Achievable Energy Efficiency (AAEE) Mid value associated with that case, which are totaled in the last row.

Table 2 System Load Summer Peak Forecast Summary (1 in 5 year, with AAEE Mid included)

Division Name	2029
HUMBOLDT	121
N. COAST	800
N.VALLEY	935
SACRAMENTO	1206
SIERRA	1319
NORTHBAY	689
EAST BAY	878
DIABLO	1662
S.F.	945
PENNSULA	954
STOCKTON	1646
STANISLAUS	315
YOSEMITE	998
FRESNO	2584
KERN	2034
MISSION	1392
DE ANZA	1060
SAN JOSE	1918
CENCOAST	638
LOSPADRS	530
AREA TOTALS	22,624
AAEE (Mid)	-1451

Generation Dispatch

For the summer peak scenario, heavy imports are modelled coming into California from the northwest. In addition to the heavy imports the NorCal Hydro is dispatched at 80%. Leaving no capacity on many 500 kV lines in the northern part of PG&E's system. Since peak load was identified as 7pm in the CAISO Transmission Planning Process solar is not dispatched. Wind is however dispatched quite high. Thermal units are to be modelled to meet net qualifying capacity submitted to the CAISO by the generator owner the same holds for QF generating units.

For the spring off peak scenario heavy exports are modelled from California to the Northwest. With loads modelled quite low the generation assumptions for the non-peak scenarios were developed utilizing historical data. Solar is dispatched high since load is identified as 1 pm and Wind is dispatched at 55%. Thermal units may be modelled off-line or dispatched very low. Peakers are modelled off-line.

Renewable Generation Dispatch

Table 3 Renewable Generation Dispatch

PTO	Scenario	Day/Time (PST)	BTM-PV			Transmission Connected PV			Transmission Connected Wind			% of managed peak load		
		2029	PGE	SCE	SDGE	PGE	SCE	SDGE	PGE	SCE	SDGE	PGE	SCE	SDGE
CAISO	Summer Peak	9/4 HE 19	0%	0%	0%	0%	0%	0%	93%	54%	22%	93%	100%	97%
CAISO	Spring Off Peak	4/7 HE 13	80%	81%	79%	100%	98%	98%	55%	54%	22%	21%	26%	17%

Steady State Power Flow Analysis

Basecase Assumptions

PG&E uses a WECC base case to model the external WECC system merged with a PG&E seed case to model PG&E's system. The seed case is used for all other steady-state analyses. The topology of the seed case is consistent with data that is submitted for WECC base cases. This basecase is then approved by the CAISO through the Transmission Planning Process to complete reliability studies.

Power flow analyses were performed using PG&E's 2019 Series Summer Peak Bulk System base cases for 2029. Category P1 contingencies (L-1, T-1, G-1), P6 and P7 were simulated for each of the proposed alternatives for all base case scenarios. The analysis of these contingencies helps identifying low or high voltages also diverged cases could indicate either voltage instability or a possibly voltage collapse requiring further investigation. Contingencies also help identify any potential thermal overloads due to reduced reliability on the electric transmission grid.

Projects modelled in the studied basecases include projects approved through the CAISO Transmission Planning Process to be implemented in the next 10 years.

Two (2) power flow base cases will be used to evaluate the transmission system impacts of the Project. While it is impossible to study all combinations of system load and generation levels during all seasons and at all times of the day, these base cases represent extreme loading and generation conditions for the study area.

- 2029 Summer Peak Full Loop Base Case:

Summer peak power flow base cases will be used to evaluate the transmission system impacts of the interconnection of the Project on the PG&E system. Power flow analysis will be performed using the most recent PG&E 2029 Summer Peak Base Case (in General Electric Power Flow format). This base case will model a 1-in-5 year adverse weather load level for the impacted areas in the system. The base case will also be modified to represent extreme loading and generation conditions for the study area.

- 2029 Spring Off-Peak Full Loop Base Case:

Power flow analysis will also be performed using PG&E's 2029 Spring Off-Peak Base Case (in General Electric Power Flow format) in order to evaluate potential congestion on transmission facilities during the Off-Peak system conditions. The loads in this base case will be about 20-30% of the summer peak loads.

Contingencies

The contingencies evaluated for steady state studies are a standard contingency set used by PG&E's Transmission Planning Department, the list is created annually. The base cases will be used to simulate the impact of the interconnection during normal operating conditions and with all single (Category "P1 and P7") and multiple (Category "P6") contingencies in PG&E's impacted areas and Bulk Transmission System to be assessed.

System Planning simulations were performed to identify any possible thermal, or voltage violations resulting from the interconnection of additional generation connected to PG&E's Transmission System with all facilities in service. Results of the analysis were evaluated against NERC TPL-001-4 standard.

The following criteria were used to determine acceptable performance with the Standards:

Category P0: For normal operating conditions, no facilities shall exceed their applicable facility ratings or exceed the desired voltage range.

Category P1: For single contingency scenarios, no facilities shall exceed their applicable facility ratings nor shall they exceed the desired voltage.

Category P6: (Multiple Contingency) For a single contingency followed by system adjustment and then overlapped with another single contingency, no facilities shall exceed their applicable facility ratings nor shall they exceed the desired voltage.

Category P7: (Multiple Contingency) For the loss of any two adjacent circuits on common structures, no facilities shall exceed their applicable facility ratings nor shall they exceed the desired voltage.

Reliability Standards, Study Criteria, and Methodology

Power flow analyses will be performed to ensure that PG&E's transmission system remains in full compliance with NERC, WECC, and CAISO planning standards. The results of these power flow analyses will serve as informational only that an evaluation of the reliability impact of this new facility and its connection to interconnected transmission systems has been performed. Since the study is used for informational purposes only PG&E's obligations with NERC as the registered Transmission Owner for the PG&E transmission system will not need to communicate the results for this interconnection to the CAISO, or other neighboring entities that may be impacted, for coordination and incorporation of its transmission assessments. Input from the CAISO and other neighboring entities will be solicited to ensure coordination of transmission systems, and such solicitation if the project moves forward and is submitted into the CAISO interconnection process.

The criteria used in evaluating the performance of the Transmission System are the current North American Electric Reliability Corporation (NERC) Reliability Standards, and WECC regional criterion, including the following:

- TPL-001-WECC-CRT-3 – Transmission System Planning Performance
- TPL-001-4 – Transmission System Planning Performance Requirements

Cost Methodology

Costs provided are non-binding and not based on any Transmission Owner preliminary engineering and design. Costs were based on the 2020 PG&E Proposed Generator

Interconnection Unit Cost Guide[1] submitted to the CAISO for 3rd party interconnections to use for high level cost estimates. More detailed estimates are available once the project has been submitted through the CAISO Interconnection Study Process. Therefore costs provided are subject to modification. Costs also do not include environmental and permitting requirements. These sorts of costs can not be provided accurately until the project scope has been further developed to address the exact location and route of the project.

The Unit Cost Guide provides per unit cost per equipment. Notes are also provided within the document to establish multipliers for various conditions. These multipliers may have been utilized to obtain more accurate costs.

For the range of costs, the AACE Level 5 costs adders were utilized. The AACE level 5 guidance was applied to accurately reflect the early stage of the project. The AACE level 5 multiplier of +100% was included. For greater details on AACE guidance please refer to http://www.aacei.org/toc/toc_17r-97.pdf

Costs provided are in 2020 dollars. If parties are interested in cost estimating done in constant dollars and then escalated over the years during which the project will be constructed and then in turn arriving at project costs in nominal dollars. Please refer to the table below. Costs provided in this report were not escalated.

Current PTO Escalation Rates:

	2020	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*
Escalation Rates	2.50%	1.70%	1.70%	2.10%	2.30%	2.30%	2.30%	2.40%	2.40%	2.10%	2.30%
2019 Escalation Factors	1.000	1.017	1.034	1.056	1.080	1.105	1.131	1.158	1.185	1.210	1.238

Mathematical formula = Cost in Nominal Dollars = Cost in Constant Dollars x Escalation Factor

Other Cost Assumption	**Explanation**
All labor is straight time and based on a 5 day work week schedule. Overtime may be required due to clearances and work hour restrictions to meet project schedules.	
Contingency factor for New Transmission Line: 35%, Contingency for Reconductoring Transmission Line (assuming 25% tower modification and no foundation issue): 50%. Contingency factor for Substation Equipment and Installation: 0% (zero %)	Accuracy of the cost estimate for budgeting pupose is based on level of detail engineering completed.
Owner's Representative Fee for EPC construction: 10% of the total project cost	Additional cost for PTO to manage,monitor and provide

[1] http://www.caiso.com/informed/Pages/StakeholderProcesses/ParticipatingTransmissionOwnerPerUnitCosts.aspx.

	technical oversight of the project
Unit costs include costs to procure materials, installation, engineering, project management costs, home office costs, and contingency	
Unit costs exclude allocated corporate overhead and AFUDC (will be added to total cost estimates)	
Unit costs exclude generator's responsibility for Income Tax Component of Contribution (ITCC), (will be added to total cost estimates, if required)	
Unit costs exclude environmental monitoring and mitigations	
Transmission line cost per mile assumes conventional construction	
Cost per mile of T\L requiring helicopter construction (or deconstruction) will have higher than published per-unit cost, the labor component of helicopter construction is incrementally higher, which is not included in the per-unit cost	
The unit costs assume that operational clearances are available as required.	
Installations at 500kV are rare for generation interconnection projects in PG&E's service area and good cost data is not available. PG&E will have to develop 500 kV cost on a case-by-case basis.	
The estimated costs here do not include any applicable ITCC tax.	
Cost estimates assume that the project site has regular soil conditions and is not located in an extra high seismic zone as identified in PG&E DCM 073102 nor in a locations consisting of the following conditions: liquefiable soils, expansive soils, unstable soils, susceptible to rupture, high ground water table (less than approximately 15 feet below finish grade), FEMA flood zone(s), excessive ground settlement due to subsidence or other geological factors, and hilly and/or rocky terrain requiring substantial grading effort.	
Costs also assume that the site can be drained via customary storm water drainage infrastructure (i.e., without pump or lift stations) and not require on-site percolation basins. Costs assume including implementing Storm Water Pollution and Prevention (SWPP) and SPCC oil containment system(s).	
Cost does not include any remedial work for impact on neighboring properties.	
Costs assume that the on-site existing soil is adequate for engineered fill and can be reused on-site to achieve a balanced cut-fill earthwork volume. Costs do not assume removal of hazardous material or site remediation.	
Costs assume that the site has nearby easy access to public roads and does not include any costs for access roads outside the substation.	
Costs do not assume extensive permitting effort.	
For installing Fiber Optic on existing poles the listed cost is only for the Fiber. It does not include splicing, stringing, relocation or replacement of poles, engineering or installation cost. Installation will be performed by Transmission line Groups and they will estimate the cost on project basis.	
For installing Fiber Optic on new poles the listed cost is only for the Fiber. It does not include splicing, stringing, banding equipment, specialized Fiber, additional staging efforts, material costs, engineering or installation costs. Installation will be performed by Transmission line Groups and they will estimate the cost on project basis.	

Option 1 and 2

Background

The Humboldt Planning Area ("Humboldt") covers approximately 3,000 square miles and is located in the northwestern corner of PG&E's service territory. Some of the larger cities that PG&E serves in this area are Eureka, Arcata, Garberville and Fortuna.

Humboldt's electric transmission system is comprised of 60 kV and 115 kV transmission facilities. Generators at Humboldt Bay Power Plant (HBPP) and local Qualifying Facilities (QF) provide most electric supply to the Humboldt area. Electricity supply is supplemented by transmission from the North Valley and North Coast areas.

Humboldt Division is connected to the PG&E bulk transmission system via four transmission circuits, each about 80 to 100 miles in length. These consist of two 115 kV lines and one 60 kV line from Cottonwood Substation in the east and one 60 kV line from Mendocino Substation in the south.

The power import capability of the Humboldt transmission system is a function of the load within Humboldt and the amount of internal generation. The existing system's import capability can adequately serve the projected load growth up to 10 years and beyond as long as the existing (or equivalent replacement) generation facilities remain in service.

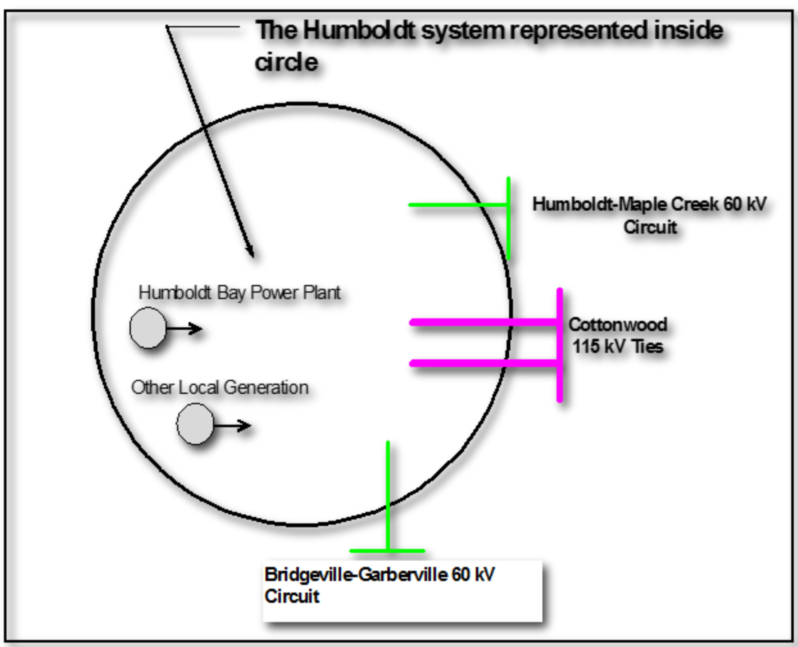


Figure 1 Humboldt Electric Transmission System connections

In the Humboldt area a dispatch of 207 MW's is modelled for local area generation, which included both QFs and the Humboldt Bay Power Plant (HBPP). The Humboldt Bay Power

Plant, operational as of August 2010, is composed of ten 16.8 MW internal combustion engine-driven generating units.

Transmission capacity concerns in the Humboldt area are mainly due to long transmission lines and the dispatch of local Humboldt generation. There are three lines that export power from the new Humboldt Bay Power Plant. When two lines are out of service, a thermal overload on the remaining line is expected during summer and winter peak loading conditions. These overloads are exacerbated when electric demand is lower in the local Humboldt and Eureka 60 kV load pocket. This overload may also be reduced by decreasing the Humboldt Bay Power Plant generation output connected to the 60 kV system.

Option 1

Two alternatives were considered in the evaluation of this option. This section provides a description and evalu alternatives investigated.

Alternative 0: Status Quo

This alternative will be assessed to better represent the issues identified in PG&E's system when the individual project interconnections are modelled without any upgrades to the system. This alternative would not be recommended as a mitigation as this alternative does not address the potential issues identified.

Alternative 1: Build new transmission lines from:

- Humboldt Bay – Humboldt No. 2 115 kV Line
- Humboldt – Trinity No. 2 115 kV Line
- Trinity – Cottonwood No.2 115 kV Line
- Bridgeville – Garberville No. 2 115 kV Line

Associated Substation reconfigurations and upgrades at substations not to be assumed in this study. Acquiring land and permitting will also not be included in this study

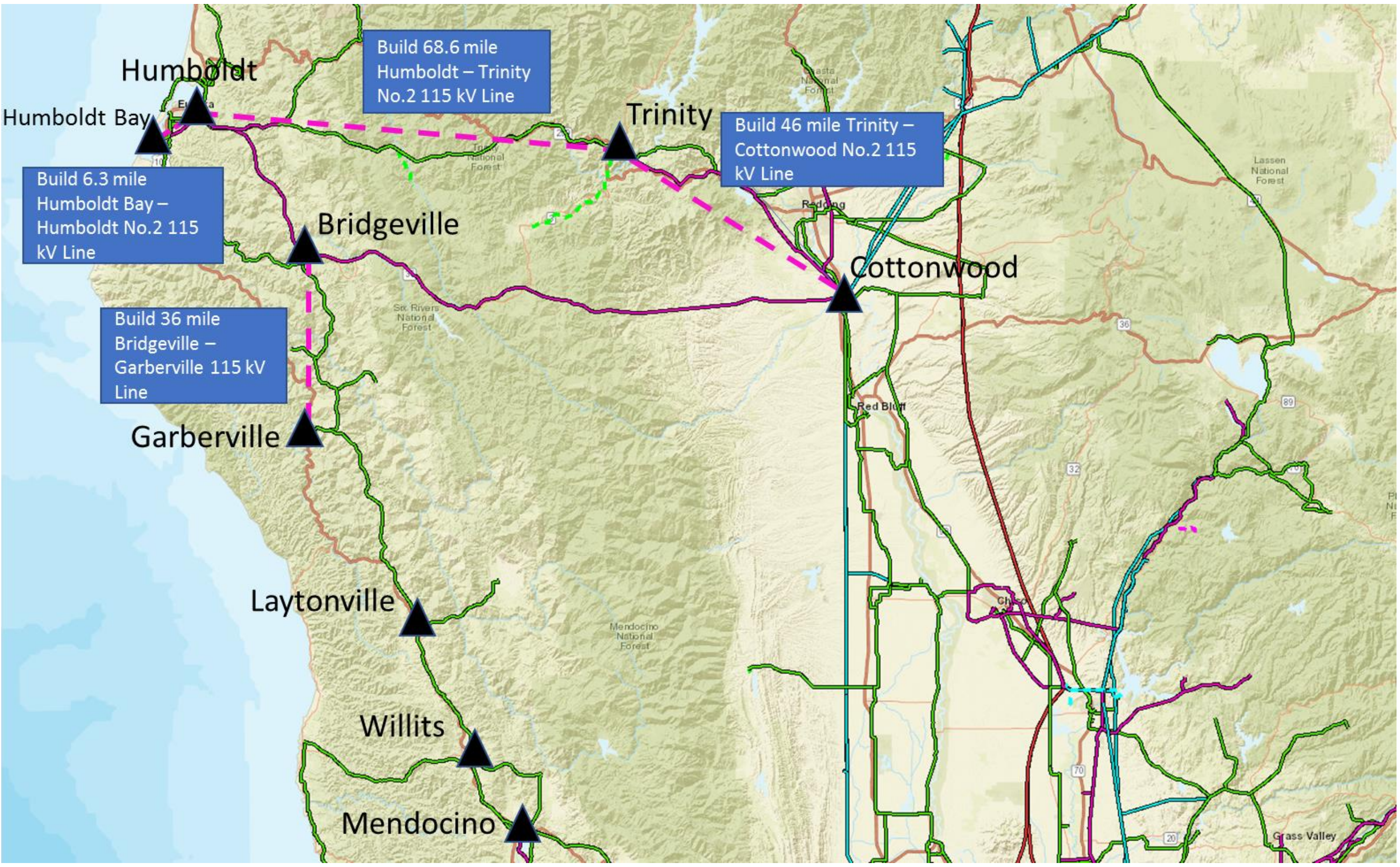


Figure 2 Option 1 Alternative 2 GIS Map

Capacity and Reliability Review

Planning assessment has identified potential thermal overloads in 2029 under peak loading conditions for normal conditions. During a normal condition the Humboldt Bay – Humboldt No. 2 115 kV line could potentially load up to 141% of its normal summer conductor ratings. Likewise, upon normal conditions the Bridgeville – Garberville 60 kV line could potentially load up to 118% of its normal summer conductor ratings. The table below shows a summary of the thermal loading with respect to the worse contingencies.

Table 4 Option 1 Alternative 1 Line Loading Summary

Transmission Line	Pre-Project Loading (normal rating)	Post-Project Loading (normal rating)
Humboldt Bay – Humboldt No. 2 115 kV Line	70%	141%
Bridgeville – Garberville 60 kV Line	103%	118%

With the current configuration, additional generation connected to the Humboldt Bay PP 115 kV bus the capacity allocated is not enough to sustain a connection as large as 48 MW's. The Bridgeville – Garberville 60 kV Line may expect marginal overloads depending on the loads and generation dispatch in pre-project scenarios. Since this overload is observed in a 10 year case and not observed in earlier study horizons no project has been approved for execution. With a system changing aggressively due to mandatory state initiatives, the loads adjusted with solar panels and battery installations, and energy efficiency programs, a 10 year definite forecast is unknown. If electrification is considered then the load forecast will vary even more. The same is true for generation dispatch as renewables are integrated in the North Coast system, support may not be needed from the Humboldt area and the overload on this particular line may be alleviated. However with the addition of generation in the Humboldt area this line will expect overloads. With so many unknowns for the long term horizon this project has not been executed and will be monitored in future studies to identify when the need is necessary.

Study Objective and Description of Alternatives

The objective of this study is to identify a long-term solution to interconnect 48 MW's to Humboldt Bay 115 kV Substation and to address the capacity and reliability issues incurred. The alternatives should alleviate the thermal and voltage violations and adequately and reliably serve the local system.

Two alternatives were considered with one being interconnecting the generator without any upgrades; and the second to build new 115 kV lines to enhance reliability. The following section provides a general description of the alternatives proposed and associated rough costs.

Alternative (1): Status Quo

This alternative is not recommended because it does not address the potential thermal overloads that could occur for normal status of the Humboldt system or for various NERC P1 (N-1) contingencies such as any 115 kV line out of service in the Humboldt area or the Bridgeville 115/60 kV Transformer out of service.

Alternative (2): Build new 115 kV transmission lines

- Build new 6.3 mile Humboldt Bay - Humboldt No. 2 115 kV Line
- Build new 68.6 mile Humboldt - Trinity No. 2 115 kV Line
- Build new 46.3 mile Trinity - Cottonwood No. 2 115 kV Line
- Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation
- Build a new 36 mile Bridgeville - Garberville No. 2 115 kV Line

The estimated rough cost for this alternative is about $365 million to $730 million.

Rough Cost Breakdown

The following table shows a unit cost breakdown for the different alternatives.

Table 5 Cost Breakdown for Option 1

OPTION 1 to interconnect 48 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt 1: Status Quo		$0
Alt 2: Build New 115 kV Transmission Lines	Build new 6.3 mile Humboldt Bay - Humboldt No. 2 115 kV Line	$14M
	Build new 68.58 mile Humboldt - Trinity No. 2 115 kV Line	$154M
	Build new 46.28 mile Trinity - Cottonwood No. 2 115 kV Line	$104M
	Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation	$12M
	Build a new 36 mile Bridgeville - Garberville No. 2 115 kV Line	$81M
	Total	**$365M - $730M**

Evaluation of Alternatives

A power flow contingency analysis was performed using the 2029 base cases against all the Category P1 (L-1, T-1, G-1), P7 and selected P6 contingencies within the study area. The results were then screened for any thermal overloads or voltage violations along with any non converging cases or excessive voltage mismatches. For this power flow analysis all base cases converged.

The table below shows the power flow analysis results.

Table 6 Power Flow Results for Option 1

NERC Category	Facility Name	Base KV	Contingency Name	Rating (N/E)	2029HS_48MW	2029SPOP_48MW	Corrective Action Plan
P0	31020 HMBOBAYPPB 115 31000 HUMBOLDT 115 1 1	115	P0: Base Case	487 Amps (N)	141.1%	95.8%	Option 1/Alternative 2
P0	Bridgeville - Garberville 60 kV Line	60	P0: Base Case	303 Amps (N)	113%	>90%	Option 1/Alternative 2
P0	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P0: Base Case	303 Amps (N)	117.8%	>90%	Option 1/Alternative 2
P0	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P0: Base Case	303 Amps (N)	112%	>90%	Option 1/Alternative 2
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT BAY-RIO DELL JCT 60kV [7100] MOAS OPENED on EEL RIVR_NEWBURG	400 Amps (E)	111.2%	>90%	Option 1/Alternative 2
P1-2	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	499 Amps (E)	122.4%	>90%	Option 1/Alternative 2
P1-2	Rio Dell Jct - Bridgeville 60 kV Line	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	113.4%	>90%	Option 1/Alternative 2
P1-2	Rio Dell - Bridgeville 60 kV Line (Carlotta - Swains Flat)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	110.3%	>90%	Option 1/Alternative 2
P1-2	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	120.6%	>90%	Option 1/Alternative 2
P1-2	Rio Dell - Bridgeville 60 kV Line (Swains Flat - Bridgeville)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	109.9%	>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	119.1%	v>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	124.7%	>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	120.1%	>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	110.5%	>90%	Option 1/Alternative 2

NERC Category	Facility Name	Base KV	Contingency Name	Rating (N/E)	2029HS_48MW	2029SPOP_48MW	Corrective Action Plan
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	400 Amps (E)	114%	>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	116%	>90%	Option 1/Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	111.5%	>90%	Option 1/Alternative 2
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT BAY-RIO DELL JCT 60kV [7100] MOAS OPENED on NEWBURG_RIODLLTP	400 Amps (E)	97.6%	>90%	Option 1/Alternative 2
P1-3	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P1-3: BRDGVLLE 115/60kV TB 1	499 Amps (E)	100.6%	>90%	Option 1/Alternative 2
P1-3	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P1-3: BRDGVLLE 115/60kV TB 1	372 Amps (E)	90.9%	>90%	Option 1/Alternative 2
P6	31080 HUMBOLDT 60.0 31092 MPLE CRK 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	350 Amps (E)	NConv (DC 137.2%)	>90%	Option 1/Alternative 2
P6	Bridgeville - Garberville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 177.8%)	>90%	Option 1/Alternative 2
P6	Bridgeville - Garberville 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	100.4%	>90%	Option 1/Alternative 2
P6	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 197.0%)	>90%	Option 1/Alternative 2
P6	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 172.7%)	>90%	Option 1/Alternative 2
P6	Garberville - Laytonville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 142.5%)	>90%	Option 1/Alternative 2
P6	Garberville - Laytonville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 144.2%)	>90%	Option 1/Alternative 2
P6	Humboldt - Bridgeville 115 kV Line	115	P6: HUMBOLDT-TRINITY 115kV [1820] & HUMBOLDT BAY-HUMBOLDT #1 60kV [7080]	400 Amps (E)	112.6%	>90%	Option 1/Alternative 2
P6	Humboldt - Trinity 115 kV Line	115	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	87.4%	>90%	Option 1/Alternative 2
P6	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	234.2%	>90%	Option 1/Alternative 2
P6	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	499 Amps (E)	214%	>90%	Option 1/Alternative 2
P6	Rio Dell - Bridgeville 60 kV Line (Carlotta - Swains Flat)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	220.9%	>90%	Option 1/Alternative 2
P6	Rio Dell - Bridgeville 60 kV Line (Swains Flat - Bridgeville)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	220.7%	>90%	Option 1/Alternative 2
P6	Rio Dell Jct - Bridgeville 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	225%	>90%	Option 1/Alternative 2
P6	Rio Dell Tap 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV	499 Amps	195.1%	>90%	Option 1/Alternative

NERC Category	Facility Name	Base KV	Contingency Name	Rating (N/E)	2029HS_48MW	2029SPOP_48MW	Corrective Action Plan
			[1810] & HUMBOLDT-TRINITY 115kV [1820]	(E)			2
P6	Trinity - Maple Creek 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 112.0%)	>90%	Option 1/Alternative 2
P7-1	Humboldt - Humboldt Bay #1 60 kV Line	60	P7-1: HUMBOLDT BAY & HUMBOLDT BAY LINES	350 Amps (E)	106.4%	>90%	Option 1/Alternative 2
P6	31556 TRINITY 60.0 31564 FRNCHGLH 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	326 Amps (E)	NConv (DC 110.4%)	>90%	Option 1/Alternative 2
P6	31564 FRNCHGLH 60.0 31566 KESWICK 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	326 Amps (E)	NConv (DC 105.8%)	>90%	Option 1/Alternative 2
P6	31566 KESWICK 60.0 31582 STLLWATR 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	281 Amps (E)	NConv (DC 110.7%)	>90%	Option 1/Alternative 2
P6	Laytonville - Willits 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	363 Amps (E)	NConv (DC 111.0%)	>90%	Option 1/Alternative 2

Status Quo – Existing 115kV System

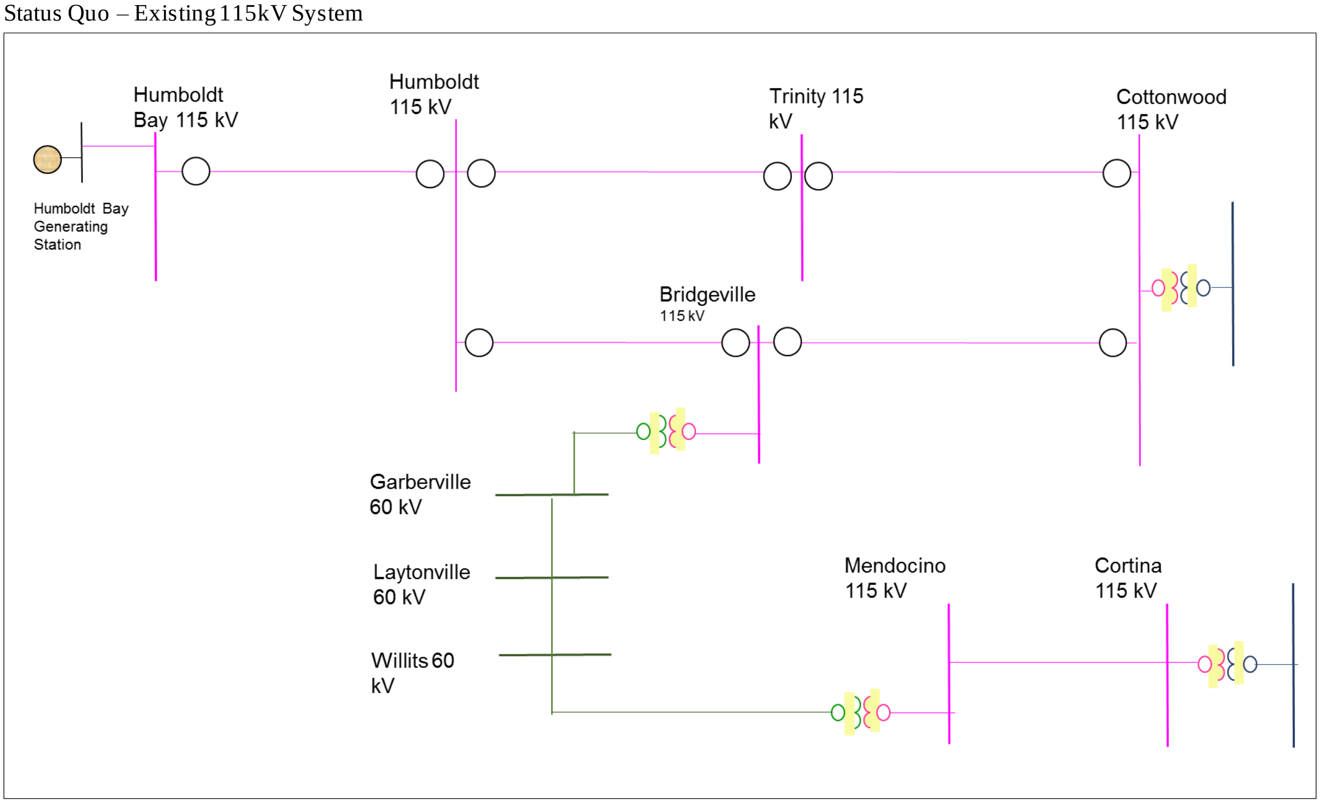


Figure 3 Existing Humboldt 115 kV System Single Line Diagram

Alternative 2 - Build new 115 kV lines

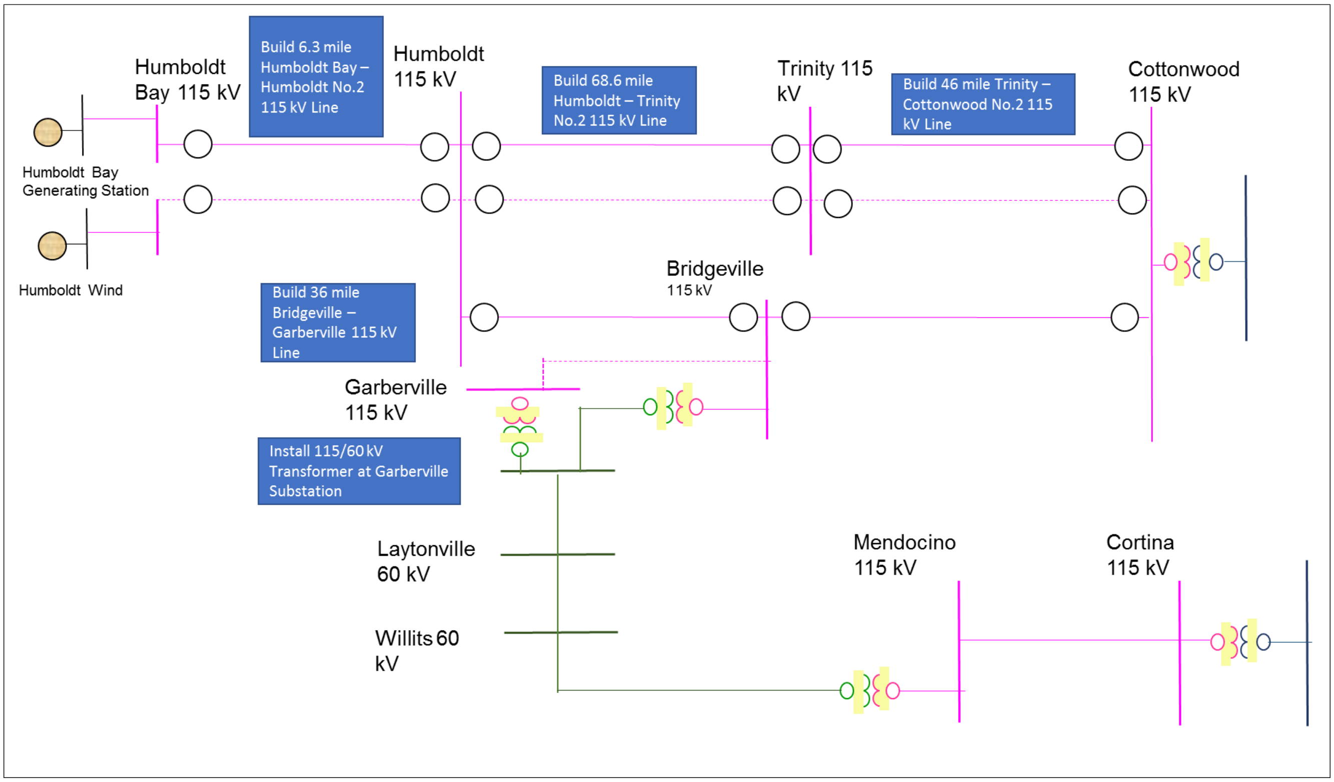


Figure 4 Alternative to Build new Humboldt 115 kV Lines Single Line Diagram

Status Quo

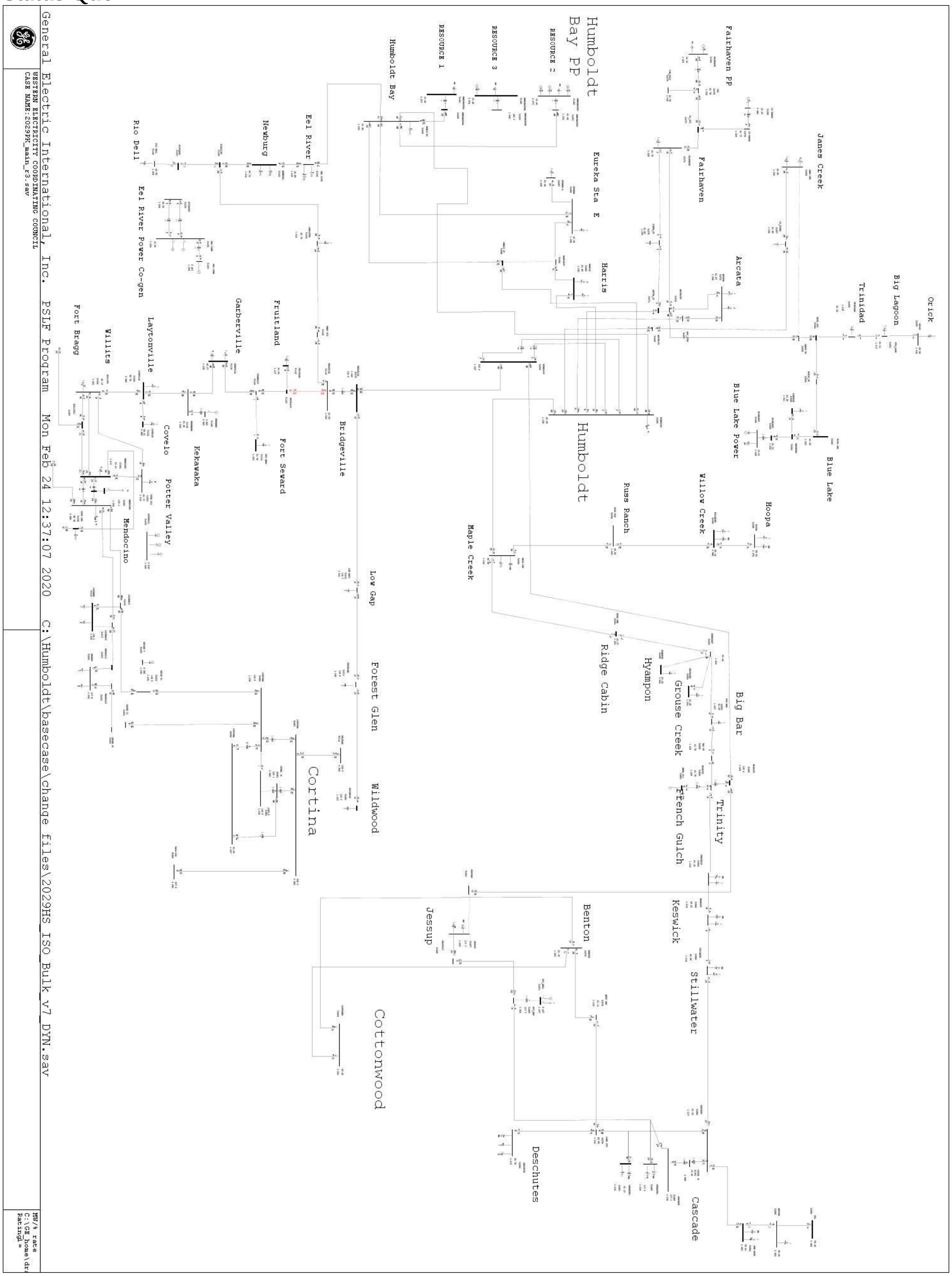


Figure 5 Status Quo 2029 Heavy Summer PSLF Power Flow (N-0)

48 MW generator Interconnected

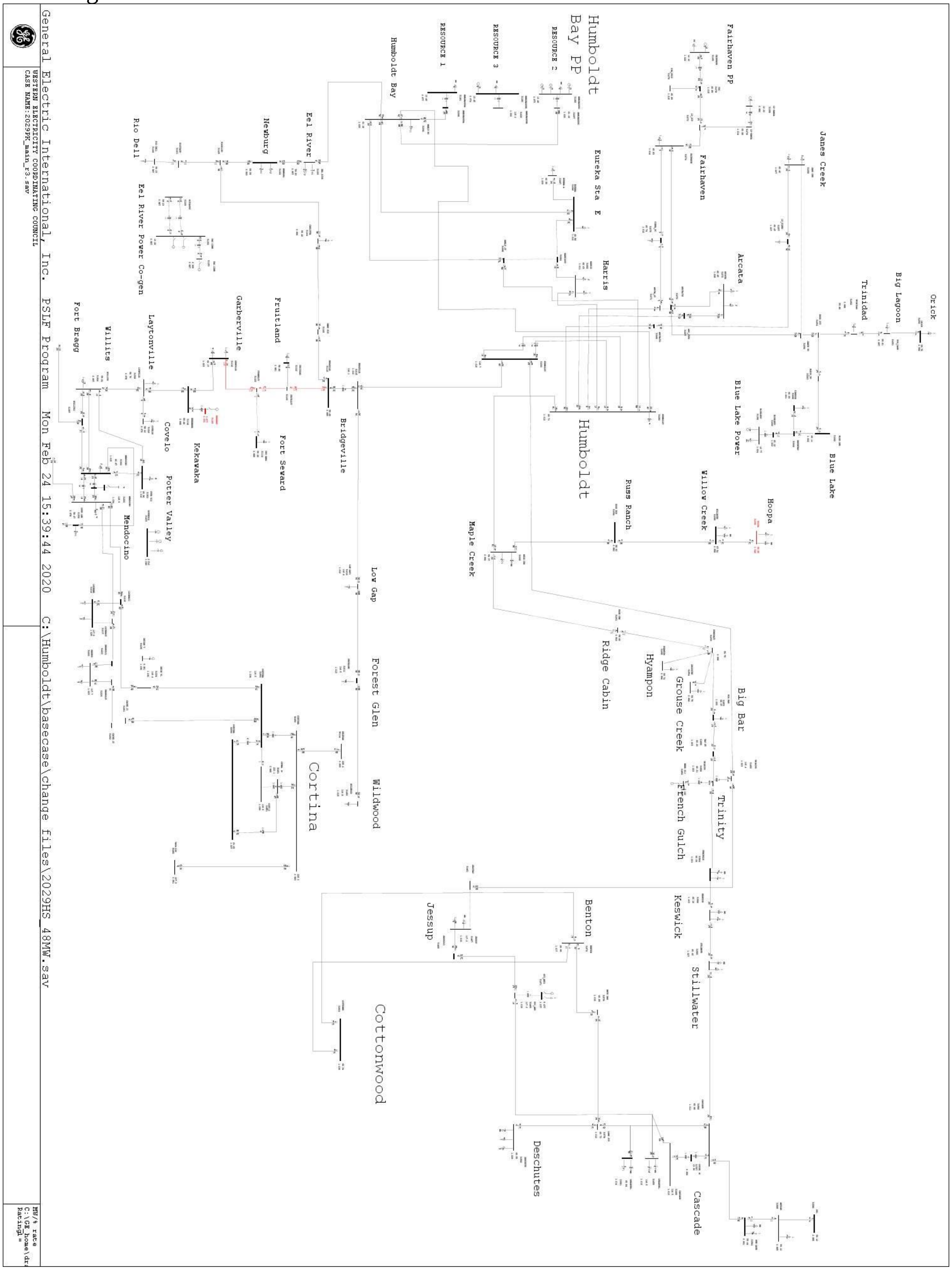


Figure 6 Option 1 2029 Heavy Summer PSLF Power Flow (N-0)

Status Quo – Power Flow

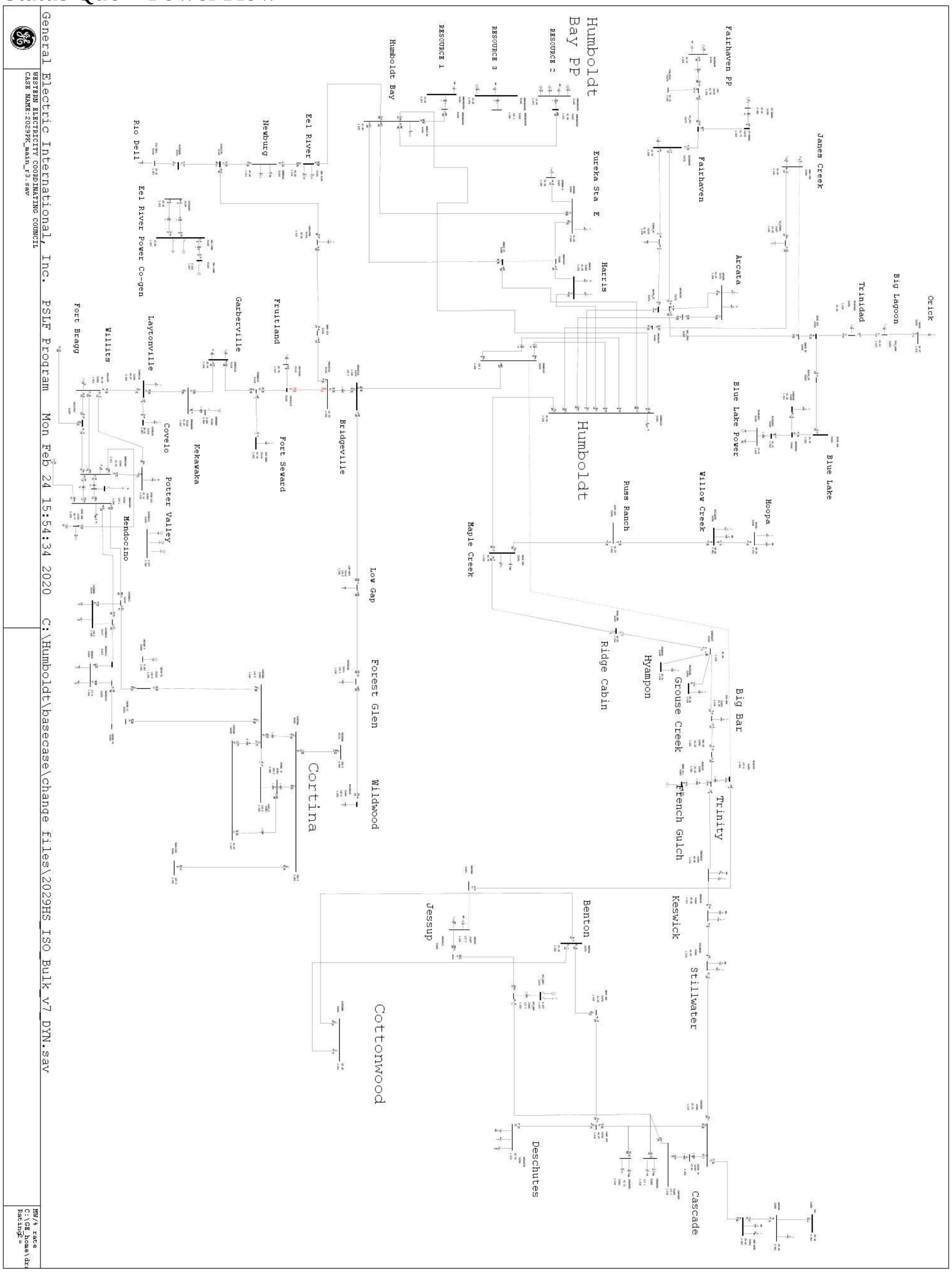


Figure 7 Status Quo 2029 Heavy Summer (N-1) Humboldt – Trinity 115 kV line Out of Service

48 MW generator Interconnected

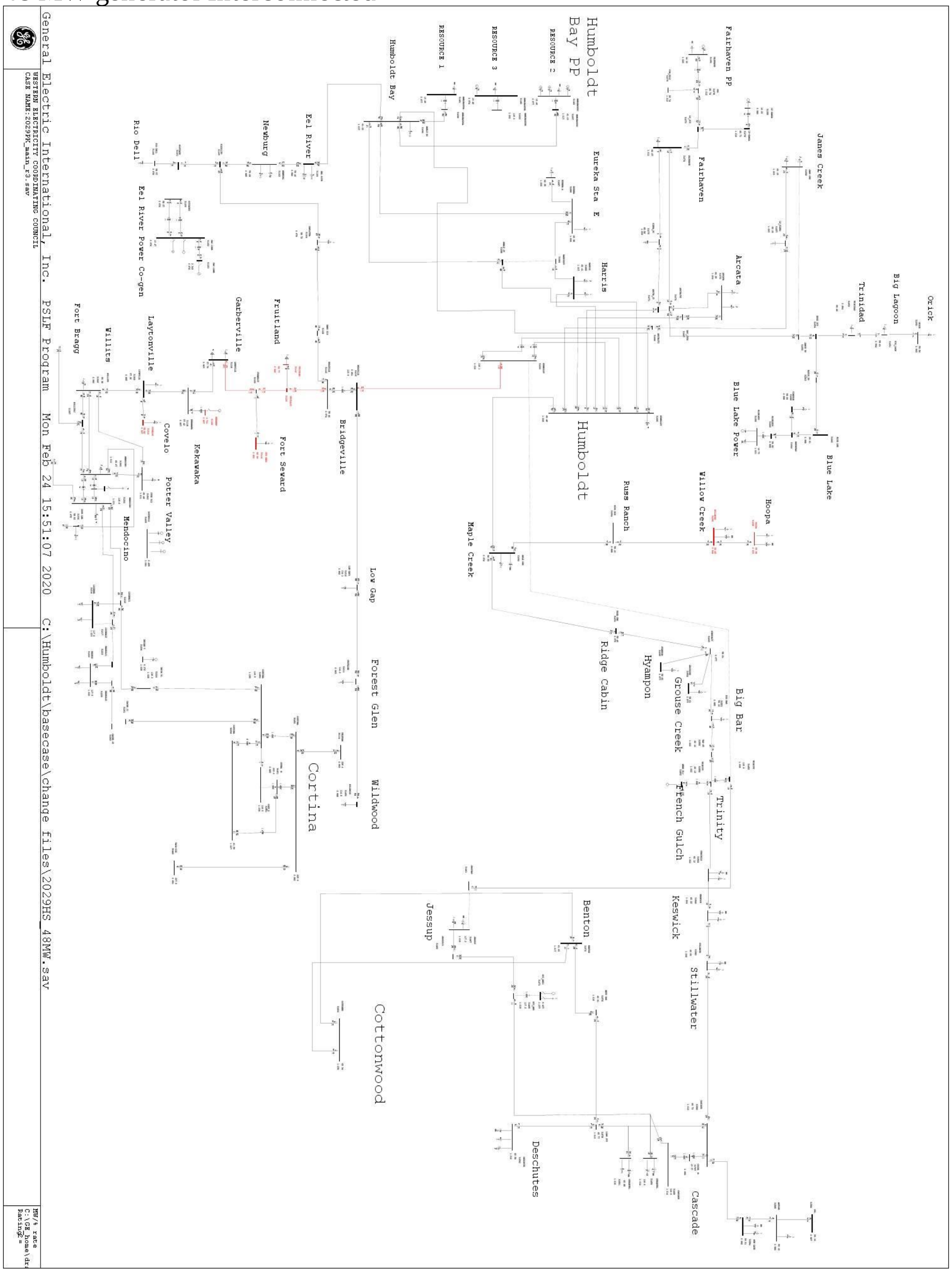


Figure 8 Option 1 2029 Heavy Summer (N-1) Humboldt – Trinity 115 kV Line Out of Service

Option 2

Two alternatives were considered in the evaluation of this option. This section provides a description and evaluation of the alternatives investigated.

Alternative 0: Status Quo

This alternative will be assessed to better represent the issues identified in PG&E's system when the individual project interconnections are modelled without any upgrades to the system. This alternative would not be recommended as a mitigation as this alternative does not address the potential issues identified.

Alternative 1: Reconductor existing transmission lines from:

- Humboldt – Humboldt Bay 115 kV
- Humboldt – Trinity 115 kV
- Humboldt – Bridgeville 115 kV
- Bridgeville – Garberville 60 kV Line
- Garberville – Laytonville 60 kV
- Laytonville – Willits 60 kV Lines

Build new line(s):

- Humboldt Bay – Humboldt No. 2 115 kV Line
- Humboldt – Trinity No. 2 115 kV Line
- Trinity – Cottonwood No.2 115 kV Line
- Bridgeville – Garberville No. 2 115 kV Line
- Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation

Associated Substation reconfigurations and upgrades at substations not to be assumed in this study. Acquiring land and permitting will also not be included in this study

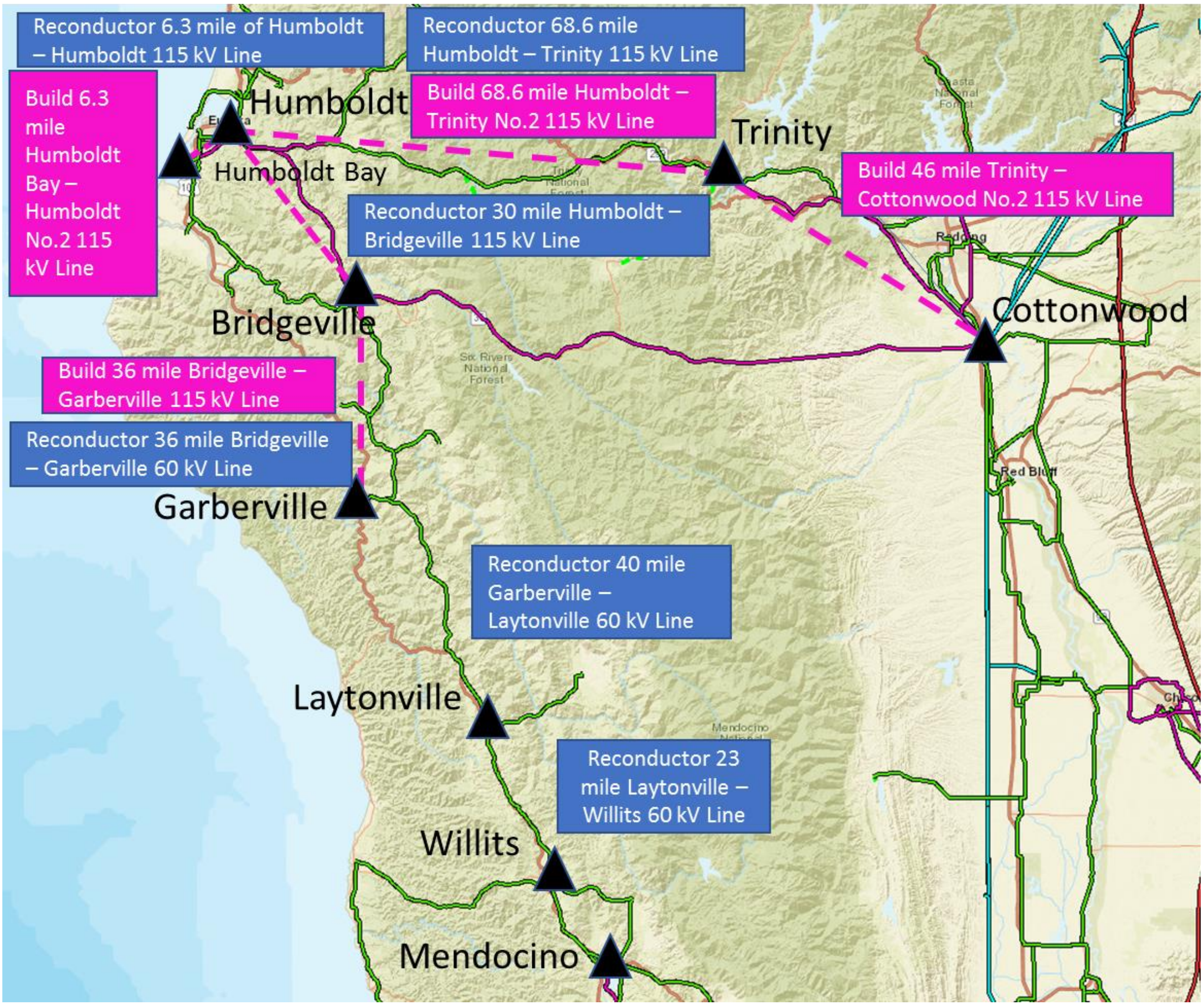


Figure 9 Option 2 Alternative 2 GIS Map

Capacity and Reliability Review

The planning assessment has identified potential thermal overloads in 2029 under peak loading conditions for normal conditions. During a normal condition the Humboldt Bay – Humboldt No. 2 115 kV line could potentially load up to 227% of its normal summer conductor ratings. Likewise, upon normal conditions the Bridgeville – Garberville 60 kV line could potentially load up to 138% of its normal summer conductor ratings. The table below shows a summary of the thermal loading with respect to the worse contingencies.

Table 7 Option2 alternative 1 Line Loadings

Transmission Line	Pre-Project Loading (normal rating)	Post-Project Loading (normal rating)
Humboldt Bay – Humboldt No. 2 115 kV Line	70%	227%
Bridgeville – Garberville 60 kV Line	103%	138%

With the current configuration, additional generation connected to the Humboldt Bay PP 115 kV bus the capacity allocated is not enough to sustain a connection as large as 144 MW's. The Bridgeville – Garberville 60 kV Line may expect marginal overloads depending on the loads and generation dispatch in pre-project scenarios. Since this overload is observed in a 10 year case and not observed in earlier study horizons no project has been approved for execution. With a system changing aggressively due to mandatory state initiatives, the loads adjusted with solar panels and battery installations, and energy efficiency programs, a 10 year definite forecast is unknown. If electrification is considered then the load forecast will vary even more. The same is true for generation dispatch as renewables are integrated in the North Coast system, support may not be needed from the Humboldt area and the overload on this particular line may be alleviated. However with the addition of generation in the Humboldt area this line will expect overloads. With so many unknowns for the long term horizon this project has not been executed and will be monitored in future studies to identify when the need is necessary.

Study Objective and Description of Alternatives

The objective of this study is to identify a long-term solution to interconnect 144 MW's to Humboldt Bay 115 kV Substation and to address the capacity and reliability issues incurred. The alternatives should alleviate the thermal and voltage violations and adequately and reliably serve the local system.

Two alternatives were considered with one being interconnecting the generator without any upgrades; and the second to build new 115 kV lines and reconductoring existing transmission lines to enhance reliability. The following section provides a general description of the alternatives proposed and associated rough costs.

Alternative (1): Status Quo

This alternative is not recommended because it does not address the potential thermal overloads that could occur for normal status of the Humboldt system or for various NERC P1 (N-1) contingencies such as any 115 kV line out of service in the Humboldt area or the Bridgeville 115/60 kV Transformer out of service.

Alternative (2): Reconductor existing transmission lines from:

- Humboldt – Humboldt Bay 115 kV
- Humboldt – Trinity 115 kV
- Humboldt – Bridgeville 115 kV
- Bridgeville – Garberville 60 kV Line
- Garberville – Laytonville 60 kV

- Laytonville – Willits 60 kV Lines

Build new line(s):

- Humboldt Bay – Humboldt No. 2 115 kV Line
- Humboldt – Trinity No. 2 115 kV Line
- Trinity – Cottonwood No.2 115 kV Line
- Bridgeville – Garberville No. 2 115 kV Line
- Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation

The estimated rough cost for this alternative is about $669 million to $1.34 billion.

Rough Cost Breakdown

The following table shows a unit cost breakdown for the different alternatives.

Table 8 Cost Breakdown for Option2

OPTION 2 to interconnect 144 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt 1: Status Quo		$0
Alt: 2 Reconductor and build new 115 kV and 60 kV Lines	Reconductor 6.3 miles of Humboldt Bay - Humboldt 115 kV Line	$14M
	Reconductor 30.3 miles of Humboldt - Bridgeville 115 kV Line	$68M
	Reconductor 68.58 mile of Humboldt - Trinity 115 kV Line	$50M
	Reconductor 36 mile of Bridgeville - Garberville 60 kV Line	$30M
	Reconductor 40 miles of Garberville - Laytonville 60 kV Line	$90M
	Reconductor 23 miles of Laytonville - Willits 60 kV Line	$52M
	Build new 6.3 mile Humboldt Bay - Humboldt No. 2 115 kV Line	$14M
	Build new 68.58 mile Humboldt - Trinity No. 2 115 kV Line	$154.2M
	Build new 46.28 mile Trinity - Cottonwood No. 2 115 kV Line	$104.25M
	Build a new 115 kV bus and install a 115/60 kV Transformer at Garberville Substation	$12M
	Build a new 36 mile Bridgeville - Garberville No. 2 115 kV Line	$81M
	Total	**$669M - $1.34B**

Evaluation of Alternatives

A power flow contingency analysis was performed using the 2029 base cases against all the Category P1 (L-1, T-1, G-1), P7 and selected P6 contingencies within the study area. The results were then screened for any thermal overloads or voltage violations along with any non converging cases or excessive voltage mismatches. For this power flow analysis all base cases converged.

The table below shows the power flow analysis results.

Table 9 Power Flow results for Option 2

NERC	Facility Name	BaseKV	Contingency Name	Rating (N/E)	2029HS_144MW	2029SPOP_144MW	Corrective Action Plan
P0	31020 HMBOBAYPPB 115 31000 HUMBOLDT 115 1 1	115	P0: Base Case	487 Amps (N)	227%	178.3	Option2/ Alternative 2
P0	Bridgeville - Garberville 60	60	P0: Base Case	303	133.1%	>95%.	Option2/

NERC	Facility Name	BaseKV	Contingency Name	Rating (N/E)	2029HS_144MW	2029SPOP_144MW	Corrective Action Plan
	kV Line			Amps (N)			Alternative 2
P0	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P0: Base Case	303 Amps (N)	138.3%	>95%.	Option2/ Alternative 2
P0	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P0: Base Case	303 Amps (N)	132%	>95%.	Option2/ Alternative 2
P0	Humboldt - Bridgeville 115 kV Line	115	P0: Base Case	400 Amps (N)	131.9%	>95%.	Option2/ Alternative 2
P0	Humboldt - Trinity 115 kV Line	115	P0: Base Case	303 Amps (N)	124.2%	>95%.	Option2/ Alternative 2
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT BAY-RIO DELL JCT 60kV [7100] MOAS OPENED on EEL RIVR_NEWBURG	400 Amps (E)	139%	>95%.	Option2/ Alternative 2
P1-2	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	499 Amps (E)	138.5%	>95%.	Option2/ Alternative 2
P1-2	Rio Dell Jct - Bridgeville 60 kV Line	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	133.6%	>95%.	Option2/ Alternative 2
P1-2	Rio Dell - Bridgeville 60 kV Line (Carlotta - Swains Flat)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	130.3%	>95%.	Option2/ Alternative 2
P1-2	Rio Dell Tap 60 kV Line	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	499 Amps (E)	122.1%	>95%.	Option2/ Alternative 2
P1-2	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	141.1%	>95%.	Option2/ Alternative 2
P1-2	Rio Dell - Bridgeville 60 kV Line (Swains Flat - Bridgeville)	60	P1-2: HUMBOLDT-BRIDGEVILLE 115kV [1810]	372 Amps (E)	130%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	131.3%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	137.2%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line	60	P1-2: BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	132.3%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	138.8%	>95%.	Option2/ Alternative 2
P1-2	31080 HUMBOLDT 60.0 31092 MPLE CRK 60.0 1 1	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	350 Amps (E)	103.9%	>95%.	Option2/ Alternative 2
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	400 Amps (E)	200%	97.5	Option2/ Alternative 2
P1-2	31010 LOW GAP1 115 31015 BRDGVLLE 115 1 1	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	562 Amps (E)	121.5%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	145%	>95%.	Option2/ Alternative 2
P1-2	Bridgeville - Garberville 60 kV Line	60	P1-2: HUMBOLDT-TRINITY 115kV [1820]	339 Amps (E)	139.8%	>95%.	Option2/ Alternative 2

NERC	Facility Name	BaseKV	Contingency Name	Rating (N/E)	2029HS_144MW	2029SPOP_144MW	Corrective Action Plan
P1-2	31011 FRSTGLEN 115 31010 LOW GAP1 115 1 1	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	562 Amps (E)	120.7%	>95%.	Option2/ Alternative 2
P1-2	Humboldt - Bridgeville 115 kV Line	115	P1-2: HUMBOLDT BAY-RIO DELL JCT 60kV [7100] MOAS OPENED on NEWBURG_RIODLLTP	400 Amps (E)	135.1%	>95%.	Option2/ Alternative 2
P1-3	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P1-3: BRDGVLLE 115/60kV TB 1	499 Amps (E)	110.5%	>95%.	Option2/ Alternative 2
P1-3	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P1-3: BRDGVLLE 115/60kV TB 1	372 Amps (E)	102.4%	>95%.	Option2/ Alternative 2
P6	31080 HUMBOLDT 60.0 31092 MPLE CRK 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	350 Amps (E)	NConv (DC 246.6%)	NConv (DC 52.0%)	Option2/ Alternative 2
P6	HMBLT BY-HARRIS 60kV Line	60	P6: HUMBOLDT BAY-HUMBOLDT #1 60kV [7080] & HUMBOLDT BAY-HUMBOLDT #2 60kV [7090]	350 Amps (E)	137.6%	>95%.	Option2/ Alternative 2
P6	31110 BRDGVLLE 60.0 31015 BRDGVLLE 115 1 1	60/115	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	99 MVA (E)	NConv (DC 100.3%)	>95%.	Option2/ Alternative 2
P6	Bridgeville - Garberville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 266.6%)	NConv (DC 208.6%)	Option2/ Alternative 2
P6	Bridgeville - Garberville 60 kV Line (Bridgeville - Fruitland Jct)	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 293.5%)	NConv (DC 214.5%)	Option2/ Alternative 2
P6	Bridgeville - Garberville 60 kV Line (Fort Seward Jct - Garberville)	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 259.1%)	NConv (DC 207.7%)	Option2/ Alternative 2
P6	Garberville - Laytonville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 224.8%)	NConv (DC 202.3%)	Option2/ Alternative 2
P6	Garberville - Laytonville 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 228.6%)	NConv (DC 191.2%)	Option2/ Alternative 2
P6	Humboldt - Bridgeville 115 kV Line	115	P6: HUMBOLDT-TRINITY 115kV [1820] & HUMBOLDT BAY-EUREKA 60kV [7070] MOAS OPENED on HUMBOLDT_HARRIS	400 Amps (E)	168.6%	98.6%	Option2/ Alternative 2
P6	Humboldt - Bridgeville 115 kV Line	115	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	400 Amps (E)	NConv (DC 133.0%)	>95%.	Option2/ Alternative 2
P6	Humboldt - Bridgeville 115 kV Line	115	P6: HUMBOLDT-TRINITY 115kV [1820] & HUMBOLDT BAY-HUMBOLDT #1 60kV [7080]	400 Amps (E)	167%	>95%.	Option2/ Alternative 2
P6	Humboldt - Trinity 115 kV Line	115	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	131.2%	99.7%	Option2/ Alternative 2
P6	Humboldt - Trinity 115 kV Line	115	P6: BRIDGEVILLE-COTTONWOOD 115kV [1110] & HUMBOLDT 115/60kV TB 2	339 Amps (E)	154.1%	>95%.	Option2/ Alternative 2
P6	Humboldt Bay - Rio Dell Jct 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	NConv (DC 256.5%	175.9%	Option2/ Alternative 2

NERC	Facility Name	BaseKV	Contingency Name	Rating (N/E)	2029HS_144MW	2029SPOP_144MW	Corrective Action Plan
					)		
P6	Humboldt Bay -Rio Dell 60 kV Line (HMBLT BY - EEL RIVR)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	499 Amps (E)	NConv (DC 235.6%)	156.3%	Option2/ Alternative 2
P6	Rio Dell - Bridgeville 60 kV Line (Carlotta - Swains Flat)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	NConv (DC 239.8%)	167.3%	Option2/ Alternative 2
P6	Rio Dell - Bridgeville 60 kV Line (Swains Flat - Bridgeville)	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	NConv (DC 225.7%)	167%	Option2/ Alternative 2
P6	Rio Dell Jct - Bridgeville 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	372 Amps (E)	NConv (DC 243.3%)	169.7%	Option2/ Alternative 2
P6	Rio Dell Tap 60 kV Line	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	499 Amps (E)	NConv (DC 211.0%)	143.2%	Option2/ Alternative 2
P6	Trinity - Maple Creek 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	339 Amps (E)	NConv (DC 219.1%)	NConv (DC 33.2%)	Option2/ Alternative 2
P7-1	Humboldt - Humboldt Bay #1 60 kV Line	60	P7-1: HUMBOLDT BAY & HUMBOLDT BAY LINES	350 Amps (E)	106.4%	>95%.	Option2/ Alternative 2
P6	31450 WILDWOOD 115 31524 COTWD_2E 115 1 1	115	P6: HUMBOLDT-TRINITY 115kV [1820] & HUMBOLDT 115/60kV TB 2	483 Amps (E)	111.5%	>95%.	Option2/ Alternative 2
P6	31452 TRINITY 115 31461 JESSTAP 115 1 1	115	P6: BRIDGEVILLE-COTTONWOOD 115kV [1110] & HUMBOLDT 115/60kV TB 2	455 Amps (E)	110.3%	>95%.	Option2/ Alternative 2
P6	31461 JESSTAP 115 31521 COTWD_1D 115 1 1	115	P6: BRIDGEVILLE-COTTONWOOD 115kV [1110] & HUMBOLDT 115/60kV TB 2	455 Amps (E)	108.1%	>95%.	Option2/ Alternative 2
P6	31556 TRINITY 60.0 31564 FRNCHGLH 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	326 Amps (E)	NConv (DC 204.0%)	NConv (DC 32.1%)	Option2/ Alternative 2
P6	31564 FRNCHGLH 60.0 31566 KESWICK 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	326 Amps (E)	NConv (DC 194.6%)	NConv (DC 30.2%)	Option2/ Alternative 2
P6	31566 KESWICK 60.0 31582 STLLWATR 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	281 Amps (E)	NConv (DC 209.2%)	NConv (DC 33.0%)	Option2/ Alternative 2
P6	31580 CASCADE 60.0 31582 STLLWATR 60.0 1 1	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	326 Amps (E)	NConv (DC 155.9%)	NConv (DC 32.6%)	Option2/ Alternative 2
P6	31580 CASCADE 60.0 31582 STLLWATR 60.0 1 1	60	P6: HUMBOLDT-BRIDGEVILLE 115kV [1810] & HUMBOLDT-TRINITY 115kV [1820]	326 Amps (E)	NConv (DC 109.4%)	>95%.	Option2/ Alternative 2
P6	Laytonville - Willits 60 kV Line	60	P6: HUMBOLDT-TRINITY 115kV [1820] & BRIDGEVILLE-COTTONWOOD 115kV [1110]	363 Amps (E)	NConv (DC 181.1%)	NConv (DC 180.3%)	Option2/ Alternative 2
P1-2	31450 WILDWOOD 115	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	483	139.3%	>95%.	Option2/

NERC	Facility Name	BaseKV	Contingency Name	Rating (N/E)	2029HS _144MW	2029SP OP_14 4MW	Corrective Action Plan
	31524 COTWD_2E 115 1 1			Amps (E)			Alternative 2
P1-2	31450 WILDWOOD 115 31011 FRSTGLEN 115 1 1	115	P1-2: HUMBOLDT-TRINITY 115kV [1820]	562 Amps (E)	120.5%	>95%.	Option2/ Alternative 2

Status Quo – Existing 115kV System

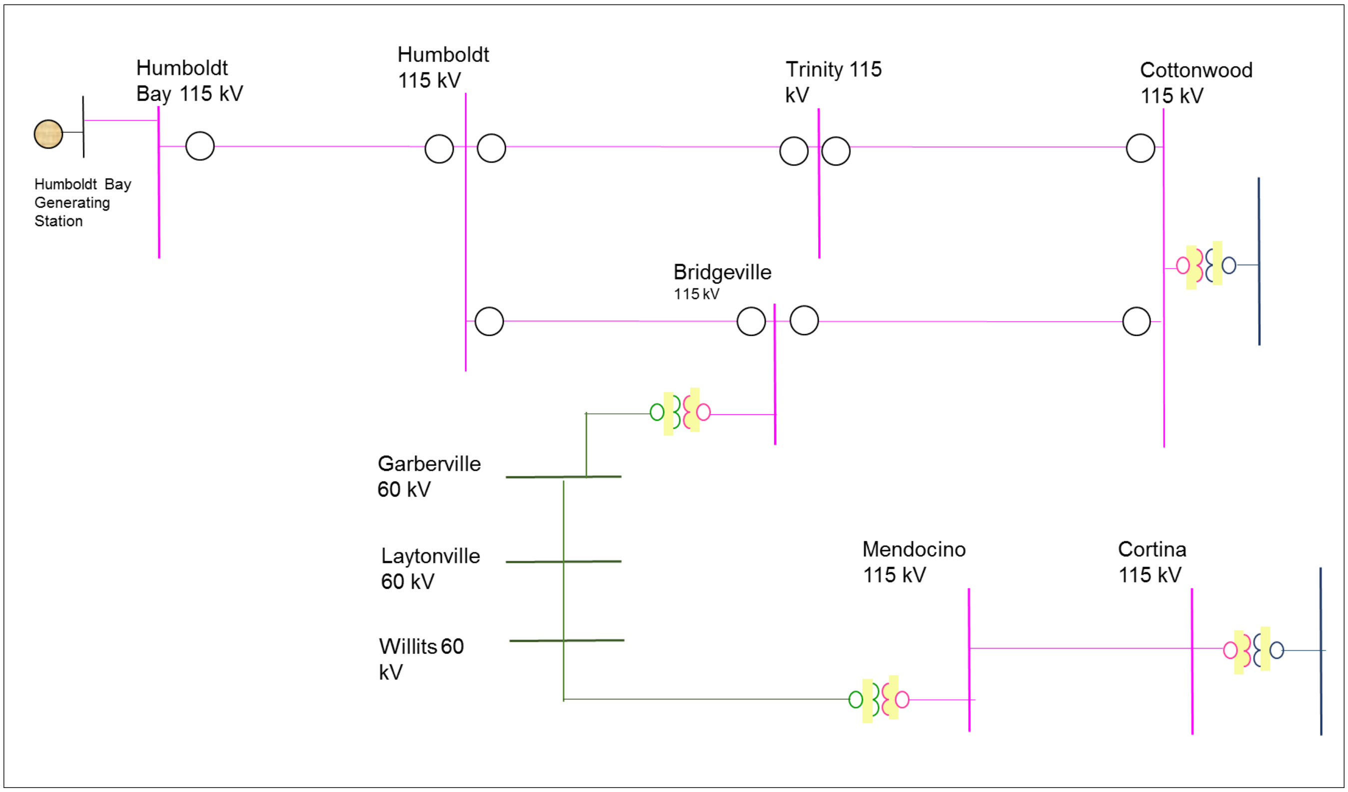


Figure 10 Existing Humboldt 115 kV System Single Line Diagram

Alternative 1

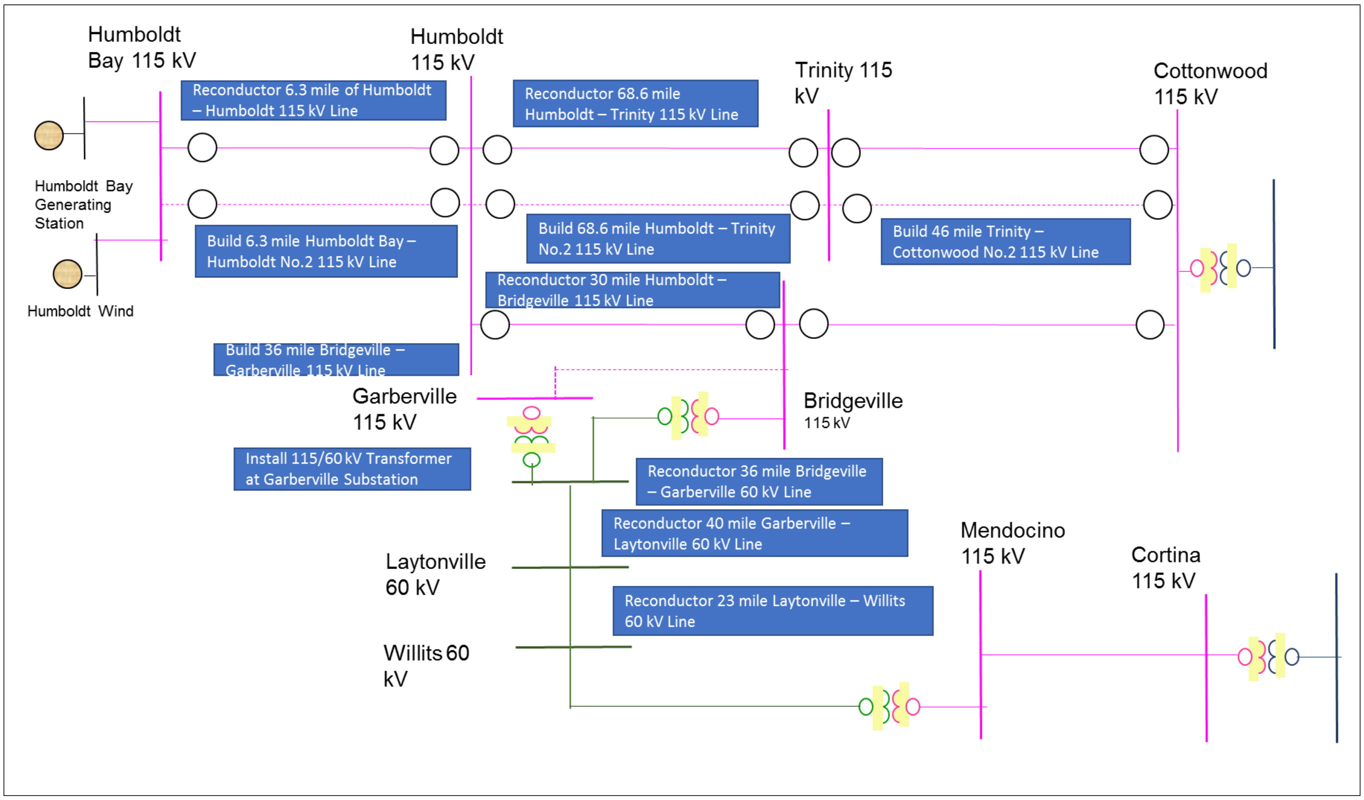


Figure 11 Option 2 Alternative 1 to Build new Humboldt 115 kV Lines and Reconductor Single Line Diagram

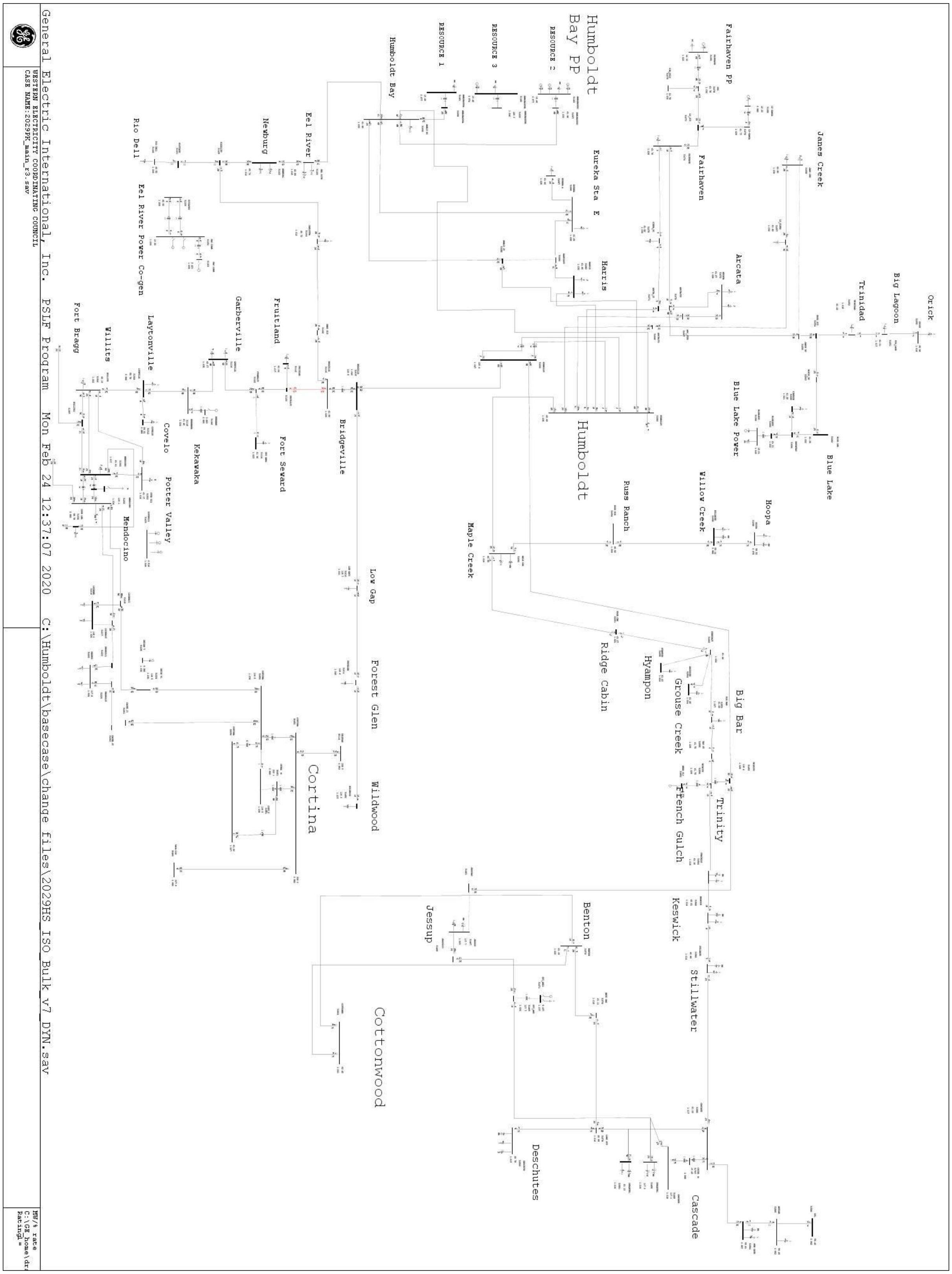


Figure 12 Status Quo 2029 Heavy Summer PSLF Power Flow (N-0)

144 MW Generator Interconnected

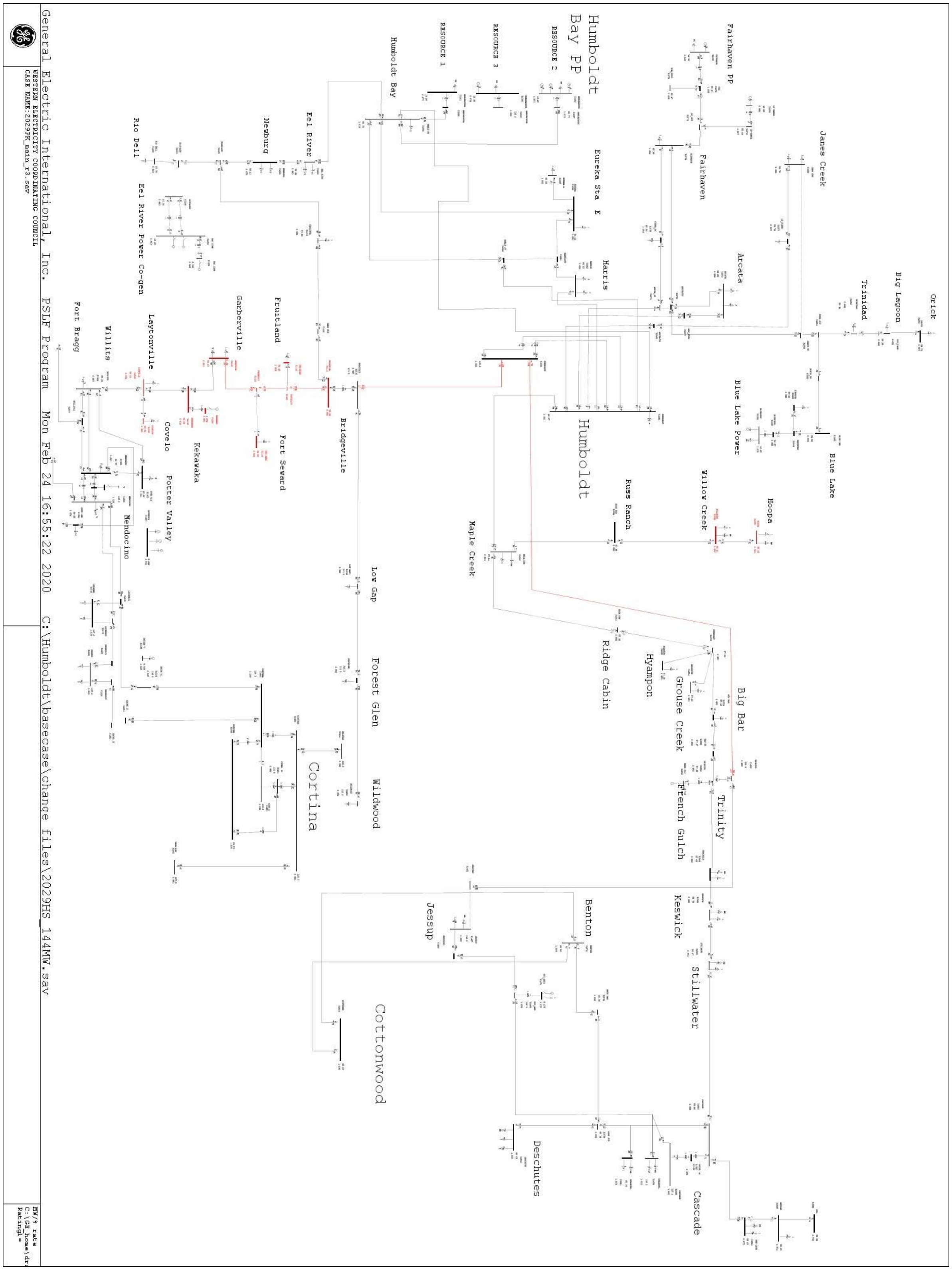


Figure 13 Option 2 Alternative 1 2029 Heavy Summer PSLF Power Flow (N-0) normal conditions

Status Quo

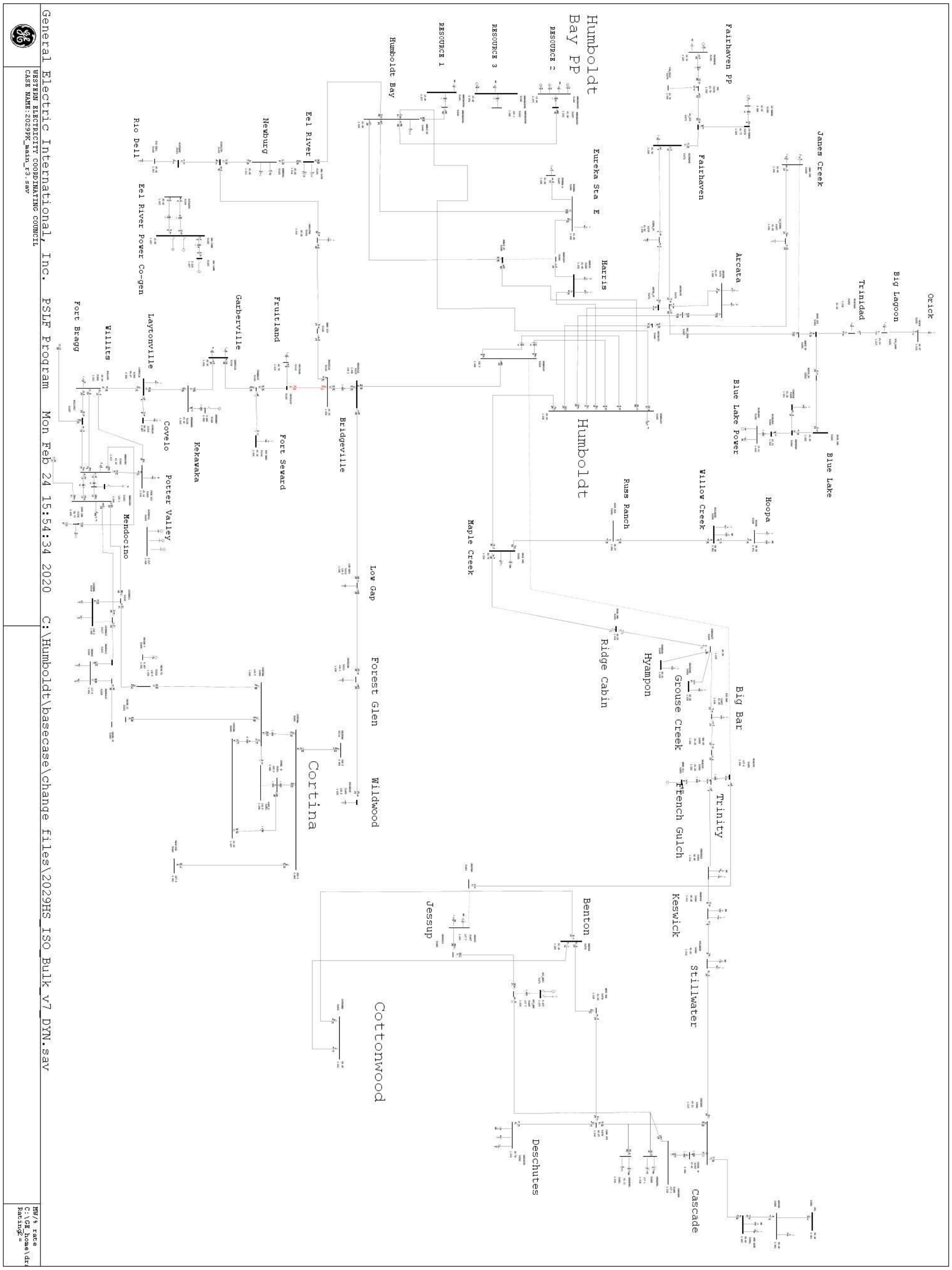


Figure 14 Status Quo 2029 Heavy Summer (N-1) Humboldt – Trinity 115 kV Line Out of Service

144 MW Generator Interconnected

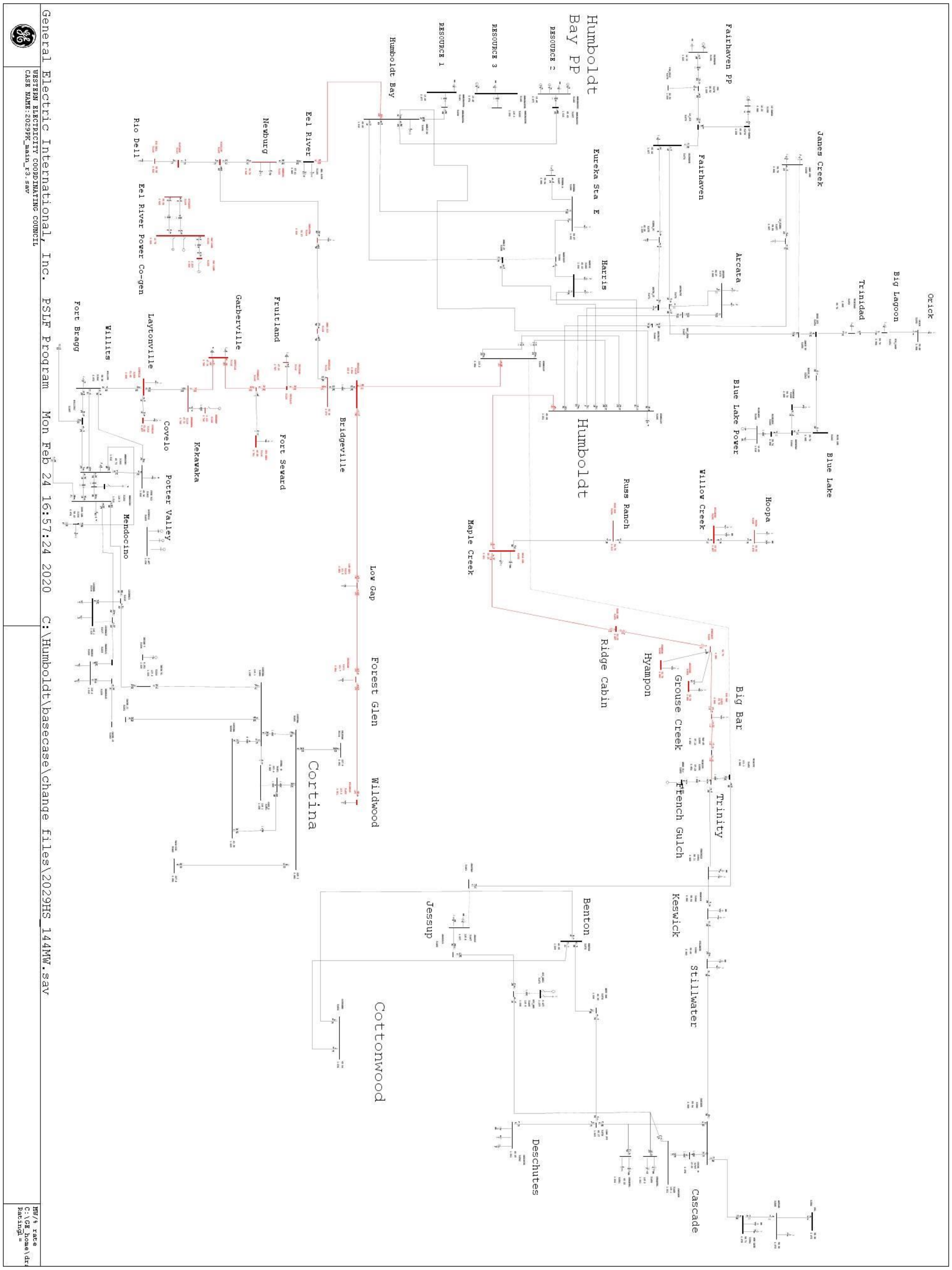


Figure 15 Option 2 2029 Heavy Summer (N-1) Humboldt – Trinity 115 kV Line Out of Service

Option 3

Three alternatives were considered in the evaluation of this option. This section provides a description and evaluation of the alternatives investigated.

Alternative 1 Background

The PG&E service territory covers approximately 70,000 square miles and is located in northern and central California. PG&E shares external electrical interconnections with BPA in the north, Southern California Edison in the south, and NV Energy in the east, in addition to numerous internal electrical interconnections within California.

Per Schatz Energy Research Center a route east is to be considered for Alternative 1. As such, a 500 kV line from the Humboldt area to Round Mountain 500 kV substation was assessed. Round Mountain 500 kV Substation is directly connected to the California – Oregon – Intertie referred to as COI.

The COI consists of three jointly owned 500 kV AC lines from Oregon to northern California, which together are recognized as a Western Electric Coordinating Council (WECC) regional transmission path, identified as Path 66. This path is shown below. Two lines of the COI are known as the Pacific AC Intertie (PACI), the third is the California Oregon Transmission Project (COTP).

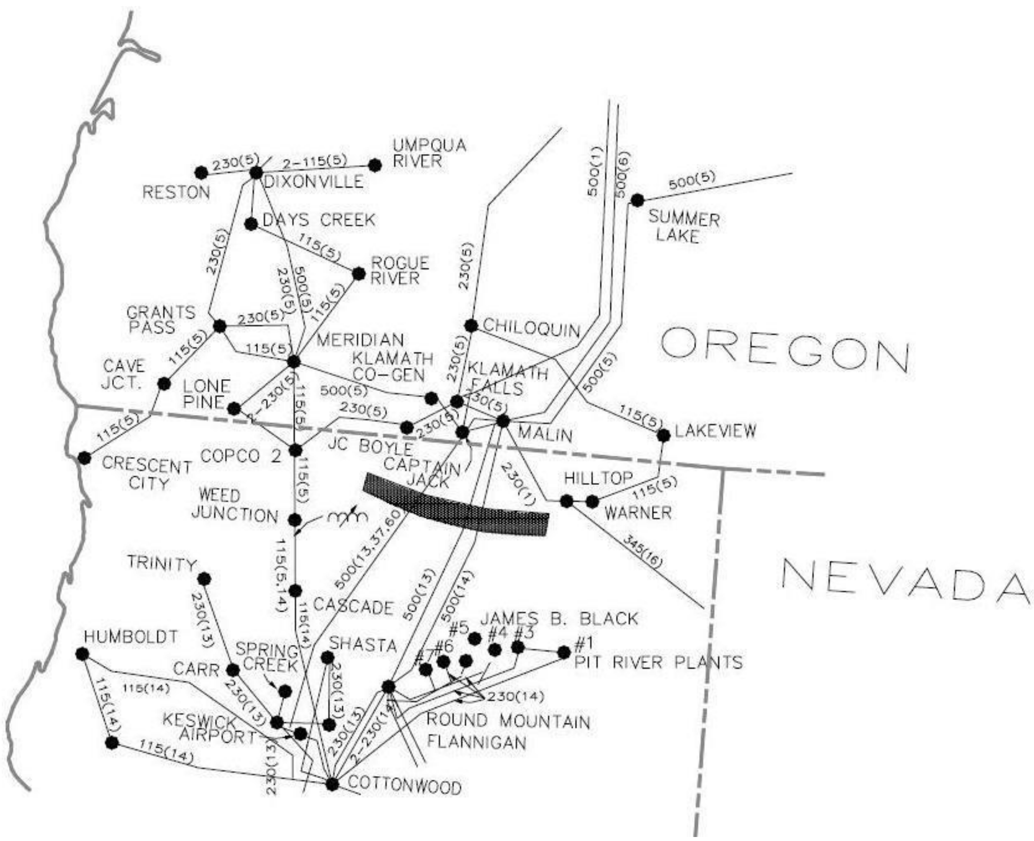


Figure 16 WECC Map of Path 66 (COI)

The nominal COI rating is 4,800 MW from north-to-south, and 3,675 MW from south to north. However, in addition to limitations due to outages, nomograms have been developed to identify simultaneous operating constraints between this path and other paths including:

The Pacific DC Intertie (Path 65),
The North of John Day (Path 73),
Hemingway-Summer Lake (Path 75), and
Borah West (Path 17).

Other factors that affect operating conditions are:
Northern California hydro generation,
Other northern California generation,
Northern California load,
Northwest hydro and thermal generation dispatch,
Northwest load levels, and
Reno-Alturas (Path 76 or NW-Sierra) flow.

The 4800 MW rating is highly dependent on interactions with other WECC Paths, Northern California Hydro (NCH) output, Northern California load, and also relies on a multifaceted Remedial Action Scheme (RAS) to support reliable power transfers.

Therefore if this alternative were to be chosen as a viable option a coordination study with all path owners and affected parties would have to be coordinated through the WECC process by performing a Path Rating Study.

Also in this informational study only power flow analysis was performed. COI is limited by voltage stability. If this option becomes viable it will be necessary to perform voltage stability studies as COI is variable. Note in such study it would also be suggested that transient stability studies also be performed.

The Round Mountain 500 kV Substation is located in the North Valley Division in the northeastern corner of PG&E’s service territory. North Valley’s electric transmission is comprised of 60, 115, 230, and 500 kV transmission facilities. The 230 kV facilities, which complement the Pacific Intertie, also run north to south with connections to hydroelectric generation facilities referred to as NorCal Hydro. Northern California Hydro (NCH) is 4100 MW of generation comprised of the USBR Central Valley Project, PG&E’s Pit and Feather River systems, CDWR’s Hyatt Thermalito units, and the units on the South Fork of the Feather River, and the North Yuba river systems. The 115 and 60 kV facilities are utilized to serve local electric demand.

In addition to the PI and COI, there is one other external interconnection to PacifiCorp. The internal transmission connections to the Humboldt and Sierra areas are via Cottonwood, Table Mountain, Palermo, and Rio Oso substations.

The major transmission paths are shown below:

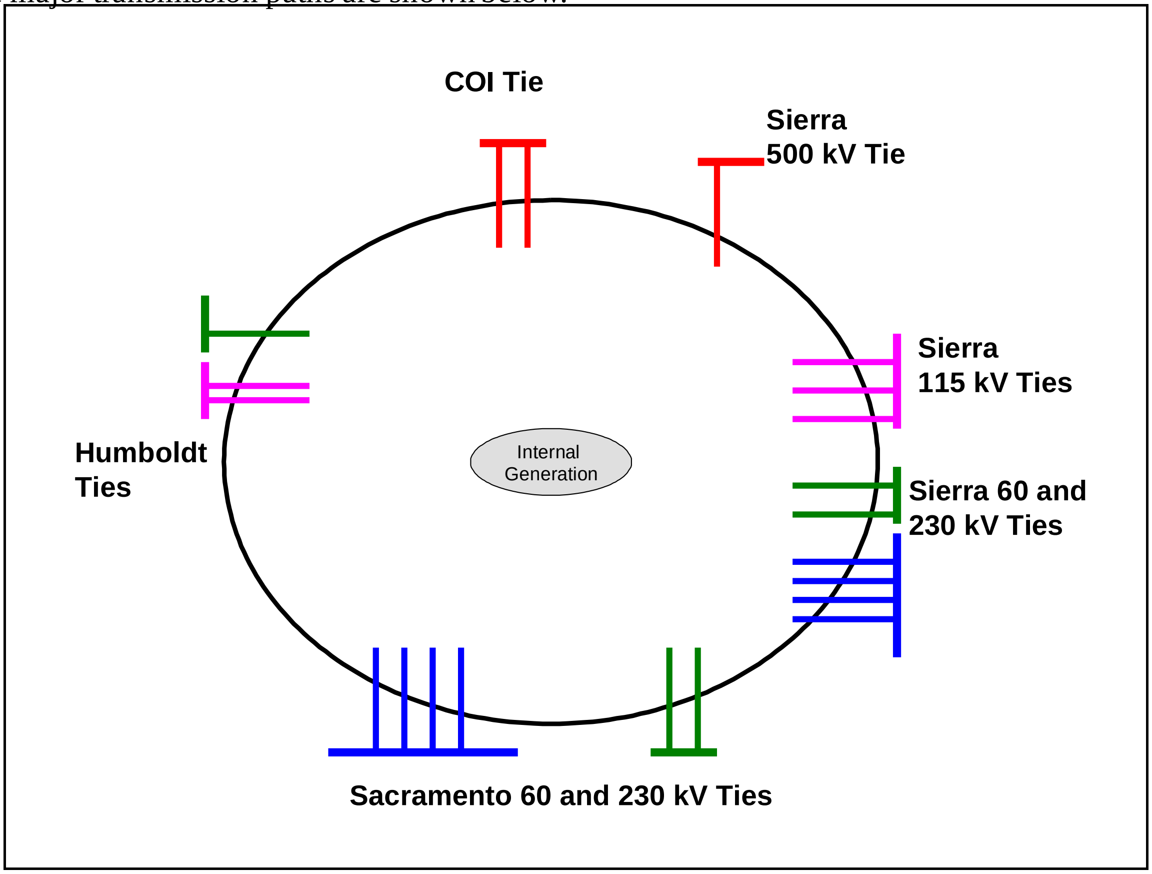


Figure 17 North Valley System Transmission connections

The EHV 500 kV Bulk system and portions of the underlying 230 kV system were assessed for overall system performance in accordance with the NERC TPL-001-4 Reliability Standard.

Alternative 1: Build new 500 KV Substation and route transmission east

- Build new 120 mile Humboldt Wind - Round Mountain 500 KV Line
- Build new 89 mile Round Mountain - Table Mountain 500 KV Line
- Build new 83 mile Table Mountain - Vaca Dixon 500 kV Line
- Build new 57 mile Vaca Dixon - Tesla 500 kV Line
- Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line

Associated Substation reconfigurations and upgrades at substations not to be assumed in this study. Acquiring land and permitting will also not be included in this study

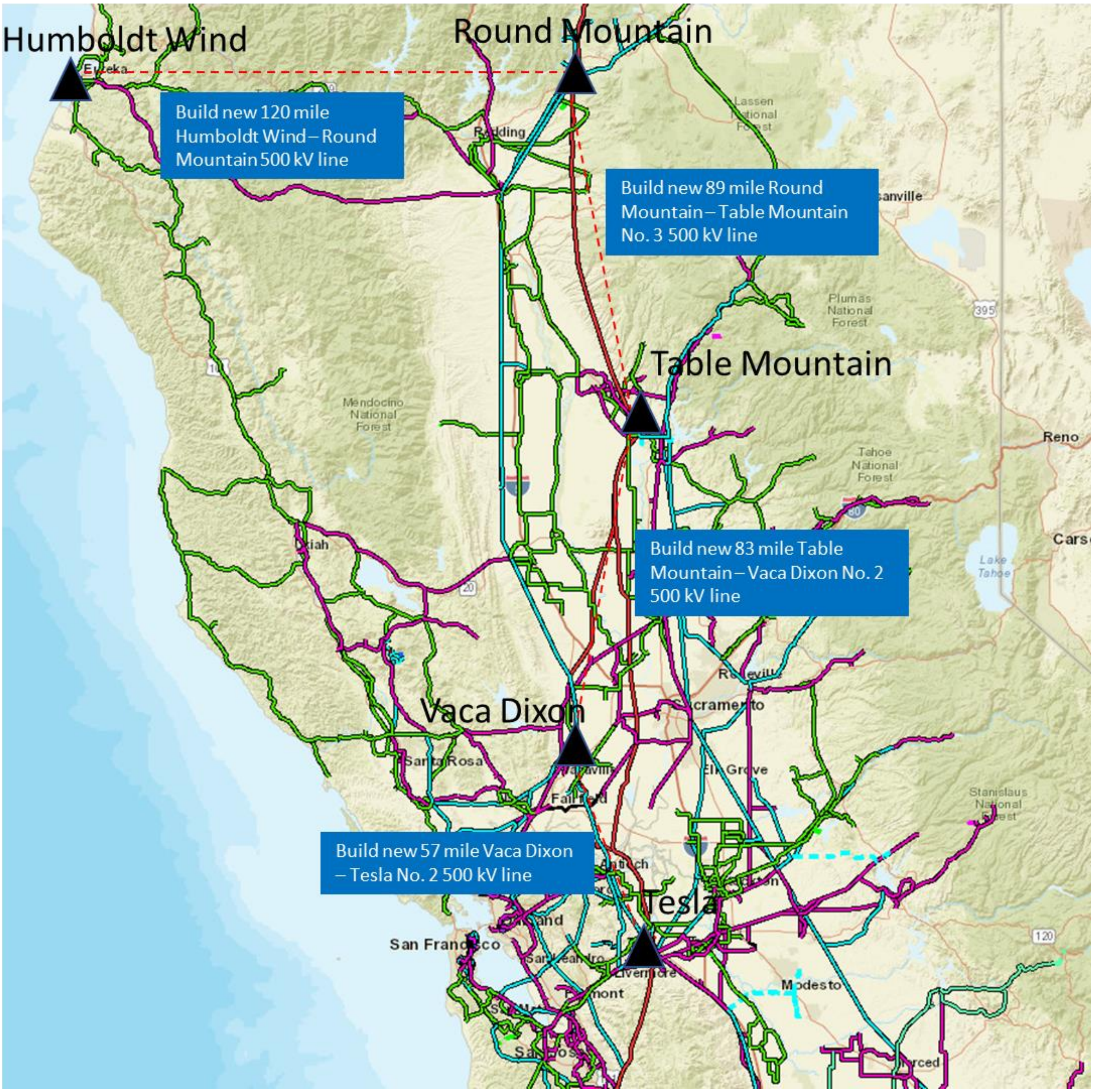


Figure 18 Option 3 Alternative 1 GIS Map

Capacity and Reliability Review

Planning assessment has identified a potential thermal overload in 2029 under peak loading conditions for normal conditions. During normal conditions the Round Mountain – Table Mountain No.1 500 kV line could potentially load up to 116%, the No. 2 line could potentially load up to 117% of its normal summer conductor ratings. Likewise, upon normal conditions the Table Mountain – Vaca Dixon 500 kV line could potentially load up to 113% of its normal summer conductor ratings. Lastly the Cayetano – USWP – JRW 230 kV line could potentially load up to 101.5% of its normal summer conductor rating. The table below shows a summary of the thermal loading with respect to the worse contingencies.

Table 10 Option 3 Alternative 1 Line Loading Summary

Transmission Line	Pre - Project Loading (normal rating)	Post - Project Loading (normal rating)	Post - Project Loading with additional 500 kV lines built (normal rating)
Round Mountain - Table Mountain No.1 500 KV Line	85%	116%	85%
Round Mountain - Table Mountain No.2 500 KV Line	86%	117%	85%
Table Mountain - Vaca Dixon 500 kV Line	84%	112%	80%
Vaca Dixon - Tesla 500 kV Line	66%	92%	120%
USWP-JRW - Cayetano 230 kV Line	98%	102%	70%

With the current configuration, additional generation connected to the Round Mountain 500 kV Substation is not feasible as status quo. With contractual obligations and reserved capacity on COI there is not enough available capacity allocated on Path 66 to sustain a connection as large as 1836 MW's. The 500 kV lines south of Round Mountain will overload due to excess power flow. Running power flow with additional 500 kV lines built in parallel with the original lines overloaded as identified in the Post – Project loading column causes the increase in powerflow on the Vaca Dixon – Tesla 500 kV line up to 120% of its normal summer conductor rating. The Vaca Dixon – Tesla No. 2 500 kV line addition was then included in the larger scope and tested to verify no other through flow issues occurred.

Evaluation of Alternative

A power flow contingency analysis was performed using the 2029 base cases against all the Category P1 (L-1, T-1, G-1), P7 and selected P6 contingencies within the study area. The results were then screened for any thermal overloads or voltage violations along with any non converging cases or excessive voltage mismatches. For this power flow analysis all base cases converged.

The table below shows the power flow analysis results.

Table 11 Power Flow Results for Option 3 Alternative 1

NERC	Facility Name	Basek V	Contingency Name	Rating	2029HS OP1	2029S POPo p1	Corrective Action Plan
P0	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230.0	System Normal	885.9A	101.4%	>95%	Alternative 1
P0	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	System Normal	2199.9A	116.1%	>95%	Alternative 1
P0	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	System Normal	2199.9A	115.9%	>95%	Alternative 1
P0	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	System Normal	2199.9A	117.1%	>95%	Alternative 1
P0	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	System Normal	2199.9A	116.9%	>95%	Alternative 1
P0	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	System Normal	2199.9A	116.1%	>95%	Alternative 1
P0	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	System Normal	2199.9A	117.1%	>95%	Alternative 1
P0	TABLE MT 500kV-TM_VD_11 500kV ckt=1	500	System Normal	2477.9A	112.6%	>95%	Alternative 1
P0	TM_VD_12 500kV-TM_VD_11 500kV ckt=1	500	System Normal	2477.9A	112.6%	>95%	Alternative 1
P0	TM_VD_12 500kV-VACA-DIX 500kV ckt=1	500	System Normal	2477.9A	111.7%	>95%	Alternative 1
P1-2	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line	1005.1A	100.2%	>95%	Alternative 1
P1-2	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Table Mountain - Vaca Dixon No.1 500 kV Line	745.0A	108.8%	>95%	Alternative 1
P1-2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Olinda - Maxwell No.1 500 kV Line	953.9A	109.5%	>95%	Alternative 1
P1-2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Tesla No.1 500 kV Line	953.9A	100.8%	>95%	Alternative 1
P1-2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Vaca Dixon No.1 500 kV Line	953.9A	110.6%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	102.3%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	105.7%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain No.2 500 kV Line	3279.9A	141.4%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	101.9%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	105.5%	>95%	Alternative 1
P1-2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Round Mountain - Table Mountain No.2 500 kV Line	3279.9A	140.9%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	103.2%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	106.6%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain No.1 500 kV Line	3279.9A	141.6%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	102.7%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	106.4%	>95%	Alternative 1
P1-2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain No.1 500 kV Line	3279.9A	141.1%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	102.3%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	105.7%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain No.2 500 kV Line	3279.9A	141.4%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Captain Jack - Olinda No.1 500 kV Line	3279.9A	103.2%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell No.1 500 kV Line	3279.9A	106.6%	>95%	Alternative 1
P1-2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain No.1 500 kV Line	3279.9A	141.6%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	230	Table Mountain - Tesla #1 500kV Line & TESLA-METCALF #1 500kV Line	1004.1A	100.7%	>95%	Alternative 1
P6-1-	CAYETANO 230kV-	230	TESLA-METCALF #1 500kV Line & METCALF-MOSSLAND	1004.1A	106.0%	>95%	Alternative 1

NERC	Facility Name	Basek V	Contingency Name	Rating	2029HS OP1	2029S POPo p1	Corrective Action Plan
1	NDUBLIN 230kV ckt=1		#1 500kV Line				
P6-1-1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	1004.1A	110.4%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & TESLA-LOSBANOS #1 500kV Line	1004.1A	102.8%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	230	Vaca Dixon - Tesla #1 500kV Line & TESLA-METCALF #1 500kV Line	1004.1A	107.4%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	230	Vaca Dixon - Tesla #1 500kV Line & TRACY-TESLA #1 500kV Line	1004.1A	100.2%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & METCALF-MOSSLAND #1 500kV Line	1005.1A	106.9%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	1005.1A	111.2%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & TESLA-LOSBANOS #1 500kV Line	1005.1A	103.8%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TRACY-TESLA #1 500kV Line & TESLA-METCALF #1 500kV Line	1005.1A	100.4%	>95%	Alternative 1
P6-1-1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	Vaca Dixon - Tesla #1 500kV Line & TESLA-METCALF #1 500kV Line	1005.1A	108.3%	>95%	Alternative 1
P6-1-1	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Tesla #1 500kV Line	745.0A	101.1%	>95%	Alternative 1
P6-1-1	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	745.0A	116.9%	>95%	Alternative 1
P6-1-1	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Tesla #1 500kV Line	745.0A	101.3%	>95%	Alternative 1
P6-1-1	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	745.0A	117.0%	>95%	Alternative 1
P6-1-1	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Table Mountain - Vaca Dixon #1 500kV Line & Vaca Dixon - Tesla #1 500kV Line	745.0A	110.4%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	953.9A	100.3%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	953.9A	109.6%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	953.9A	110.2%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Tesla #1 500kV Line	953.9A	104.3%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	953.9A	114.1%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Tesla #1 500kV Line	953.9A	104.4%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	953.9A	114.2%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Tesla #1 500kV Line & TESLA-LOSBANOS #1 500kV Line	953.9A	100.9%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Tesla #1 500kV Line & TESLA-METCALF #1 500kV Line	953.9A	102.7%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Tesla #1 500kV Line & TRACY-TESLA #1 500kV Line	953.9A	106.1%	>95%	Alternative 1
P6-1-1	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Vaca Dixon #1 500kV Line & Vaca Dixon - Tesla #1 500kV Line	953.9A	113.2%	>95%	Alternative 1
P6-1-1	LS PSTAS 230kV-NEWARK D 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & METCALF-MOSSLAND #1 500kV Line	850.0A	103.1%	>95%	Alternative 1
P6-1-1	LS PSTAS 230kV-NEWARK D 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	850.0A	109.1%	>95%	Alternative 1
P6-1-1	LS PSTAS 230kV-NEWARK D 230kV ckt=1	230	Vaca Dixon - Tesla #1 500kV Line & TESLA-METCALF #1 500kV Line	850.0A	105.4%	>95%	Alternative 1
P6-1-1	NDUBLIN 230kV-VINEYARD 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	1004.1A	100.3%	>95%	Alternative 1
P6-1-1	NEWARK E 230kV-NWK DIST 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	2339.5A	103.2%	>95%	Alternative 1
P6-1-1	NEWARK F 115kV-NEWARK E 230kV ckt=11	115/230	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	462.0MVA	100.1%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	109.8%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	105.4%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	105.3%	>95%	Alternative 1

NERC	Facility Name	Basek V	Contingency Name	Rating	2029HS OP1	2029S POPo p1	Corrective Action Plan
P6-1-1	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	126.8%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.1%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	109.6%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	105.2%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	105.2%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	126.2%	>95%	Alternative 1
P6-1-1	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.1%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	110.8%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	106.3%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	106.2%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	127.0%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #2 500kV Line	3279.9A	134.1%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.3%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	110.5%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	106.1%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	106.1%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	126.3%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #2 500kV Line	3279.9A	133.6%	>95%	Alternative 1
P6-1-1	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.3%	>95%	Alternative 1
P6-1-1	ROUND MT 230kV-COTWD_E2 230kV ckt=2	230.0	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	850.0A	106.4%	>95%	Alternative 1
P6-1-1	ROUND MT 230kV-COTWD_E2 230kV ckt=2	230.0	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Vaca Dixon #1 500kV Line	850.0A	106.5%	>95%	Alternative 1
P6-1-1	ROUND MT 230kV-COTWD_E2 230kV ckt=2	230.0	Table Mountain - Vaca Dixon #1 500kV Line & Vaca Dixon - Tesla #1 500kV Line	850.0A	100.6%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	109.8%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	105.4%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	105.3%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	126.8%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.0%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3279.9A	110.8%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3279.9A	106.3%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3279.9A	106.2%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #1 500kV Line	3279.9A	127.0%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #2 500kV Line	3279.9A	134.1%	>95%	Alternative 1
P6-1-1	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Table Mountain - Tesla #1 500kV Line	3279.9A	110.2%	>95%	Alternative 1
P6-1_2	CAYETANO 230kV-NDUBLIN 230kV ckt=1	500	TESLA-METCALF #1 500kV Line & TESLA E 230/500kV Bank #2	1004.1A	105.1%	>95%	Alternative 1
P6-1_2	CAYETANO 230kV-NDUBLIN 230kV ckt=1	500	Vaca Dixon - Tesla #1 500kV Line & TESLA E 230/500kV Bank #2	1004.1A	100.6%	>95%	Alternative 1

NERC	Facility Name	Basek V	Contingency Name	Rating	2029HS OP1	2029S POPo p1	Corrective Action Plan
P6-1_2	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & METCALF 230/500kV Bank #11	1005.1A	100.6%	>95%	Alternative 1
P6-1_2	CAYETANO 230kV-USWP-JRW 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & TESLA E 230/500kV Bank #2	1005.1A	106.0%	>95%	Alternative 1
P6-1_2	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Table Mountain - Telsa #1 500kV Line & Table Mountain 230/500kV Bank #1	745.0A	100.6%	>95%	Alternative 1
P6-1_2	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Table Mountain - Vaca Dixon #1 500kV Line & Table Mountain 230/500kV Bank #1	745.0A	120.1%	>95%	Alternative 1
P6-1_2	COTWD_E 230kV-ROUND MT 230kV ckt=3	230	Table Mountain - Vaca Dixon #1 500kV Line & VACA-DIX 230/500kV Bank #11	745.0A	109.1%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	953.9A	109.5%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Telsa #1 500kV Line & Table Mountain 230/500kV Bank #1	953.9A	103.0%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Telsa #1 500kV Line & TESLA E 230/500kV Bank #2	953.9A	100.9%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Vaca Dixon #1 500kV Line & Table Mountain 230/500kV Bank #1	953.9A	114.6%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	Table Mountain - Vaca Dixon #1 500kV Line & VACA-DIX 230/500kV Bank #11	953.9A	111.0%	>95%	Alternative 1
P6-1_2	LS PSTAS 230kV-NEWARK D 230kV ckt=1	230	TESLA-METCALF #1 500kV Line & TESLA E 230/500kV Bank #2	850.0A	102.2%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.7%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.0%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	105.6%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & ROUND MT 230/500kV Bank #1	3279.9A	140.2%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	140.2%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.3%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	108.8%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	105.4%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & ROUND MT 230/500kV Bank #1	3279.9A	139.8%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500	Round Mountain - Table Mountain #2 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	139.7%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	110.6%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Malin - Round Mountain No.1 500kV Line & ROUND MT 230/500kV Bank #1 & Round Mountain - Table Mountain No.1 500kV Line	3279.9A	122.1%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.9%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	106.5%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500 kV Line & ROUND MT 230/500kV Bank #1 & Malin - Round Mountain #2 500kV Line	3279.9A	131.1%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	140.5%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	110.2%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Malin - Round Mountain No.1 500kV Line & ROUND MT 230/500kV Bank #1 & Round Mountain - Table Mountain No.1 500kV Line	3279.9A	121.5%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.8%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	106.3%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain #1 500 kV Line & ROUND MT 230/500kV Bank #1 & Malin - Round Mountain #2 500kV Line	3279.9A	130.6%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500	Round Mountain - Table Mountain #1 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	140.0%	>95%	Alternative 1

NERC	Facility Name	Basek V	Contingency Name	Rating	2029HS OP1	2029S POPo p1	Corrective Action Plan
P6-1_2	ROUND MT 230kV-COTWD_E2 230kV ckt=2	230.0	Table Mountain - Vaca Dixon #1 500kV Line & Table Mountain 230/500kV Bank #1	850.0A	109.3%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.7%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.0%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	105.6%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #2 500kV Line & ROUND MT 230/500kV Bank #1	3279.9A	140.2%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #2 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	140.2%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Captain Jack - Olinda No.1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	110.6%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Malin - Round Mountain No.1 500kV Line & ROUND MT 230/500kV Bank #1 & Round Mountain - Table Mountain No.1 500kV Line	3279.9A	122.1%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & OLINDA 500/230kV Bank #1	3279.9A	109.9%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500/230kV Bank #1	3279.9A	106.5%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Round Mountain - Table Mountain #1 500 kV Line & ROUND MT 230/500kV Bank #1 & Malin - Round Mountain #2 500kV Line	3279.9A	131.1%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Round Mountain - Table Mountain #1 500kV Line & Table Mountain 230/500kV Bank #1	3279.9A	140.5%	>95%	Alternative 1
P6-1_2	DELEVAN 230kV-CORTINA 230kV ckt=1	230	TRACY-LOSBANOS #1 500kV Line & TRACY 500kV Bus Shunt	953.9A	100.8%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	141.4%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #1 500kV Line& TABLE MT 500kV Bus Shunt	3279.9A	142.2%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #2 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.2%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	140.9%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500.0	Round Mountain - Table Mountain #1 500kV Line& TABLE MT 500kV Bus Shunt	3279.9A	141.7%	>95%	Alternative 1
P6-1_2	RM_TM_12 500kV-TABLE MT 500kV ckt=1	500.0	Round Mountain - Table Mountain #2 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	141.7%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500.0	Table Mountain - Telsa #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.4%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500.0	Table Mountain - Vaca Dixon #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.4%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-RM_TM_21 500kV ckt=2	500.0	TRACY-TESLA #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	141.6%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500.0	Table Mountain - Telsa #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	141.9%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500.0	Table Mountain - Vaca Dixon #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	141.9%	>95%	Alternative 1
P6-1_2	RM_TM_22 500kV-TABLE MT 500kV ckt=2	500.0	TRACY-TESLA #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	141.1%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	141.4%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #1 500kV Line& TABLE MT 500kV Bus Shunt	3279.9A	142.2%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_11 500kV ckt=1	500.0	Round Mountain - Table Mountain #2 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.2%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Table Mountain - Telsa #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.4%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	Table Mountain - Vaca Dixon #1 500kV Line & TABLE MT 500kV Bus Shunt	3279.9A	142.4%	>95%	Alternative 1
P6-1_2	ROUND MT 500kV-RM_TM_21 500kV ckt=2	500.0	TRACY-TESLA #1 500kV Line & TRACY 500kV Bus Shunt	3279.9A	141.6%	>95%	Alternative 1

Alternative 1

Build New 500 kV Lines

Figure 19 REDACTED

Normal Condition (N-0)

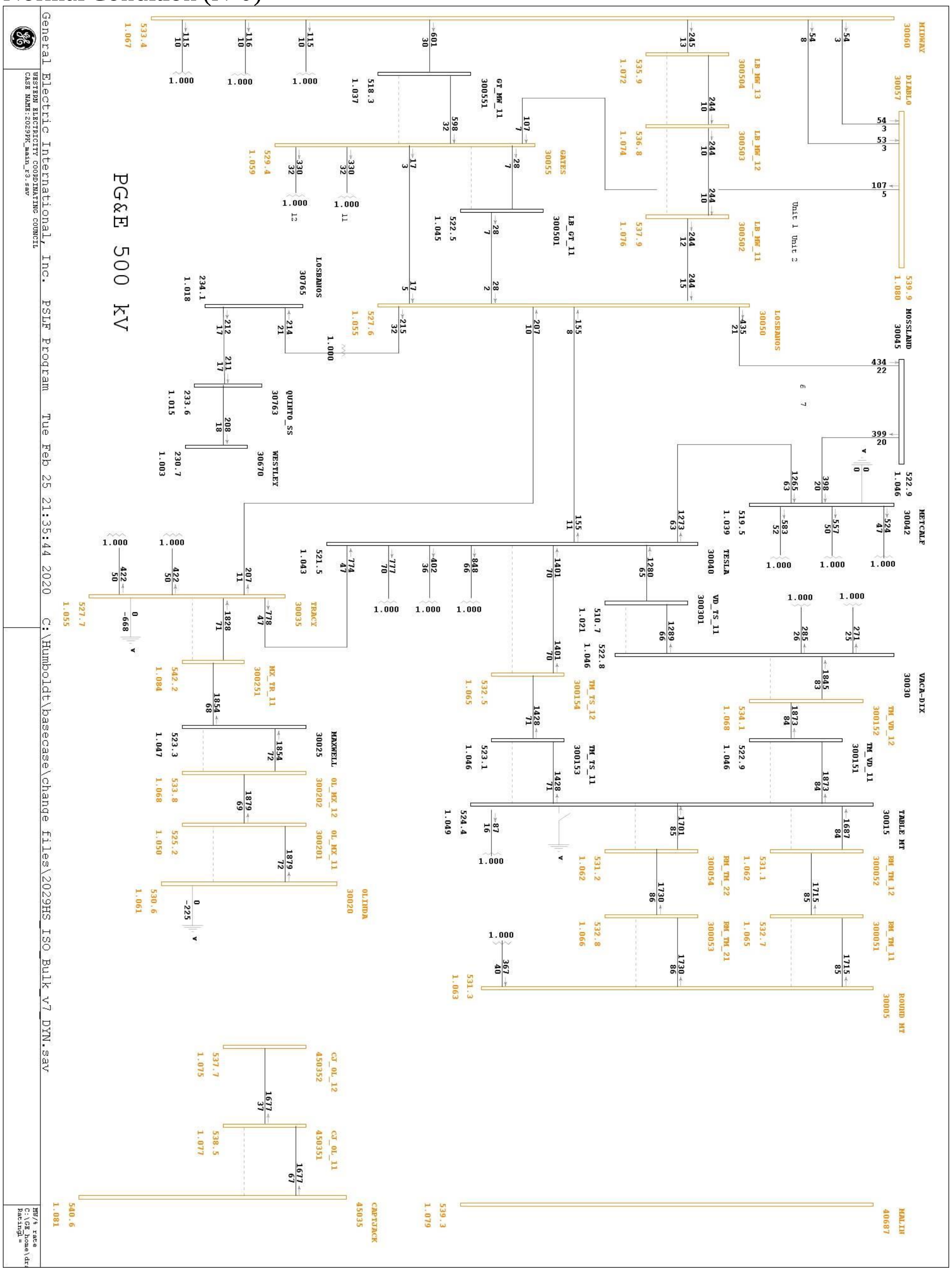


Figure 20 Status Quo 2029 Heavy Summer PSLF Power Flow (N-0)

Generator modelled with connection to Round Mountain (not complete alternative)

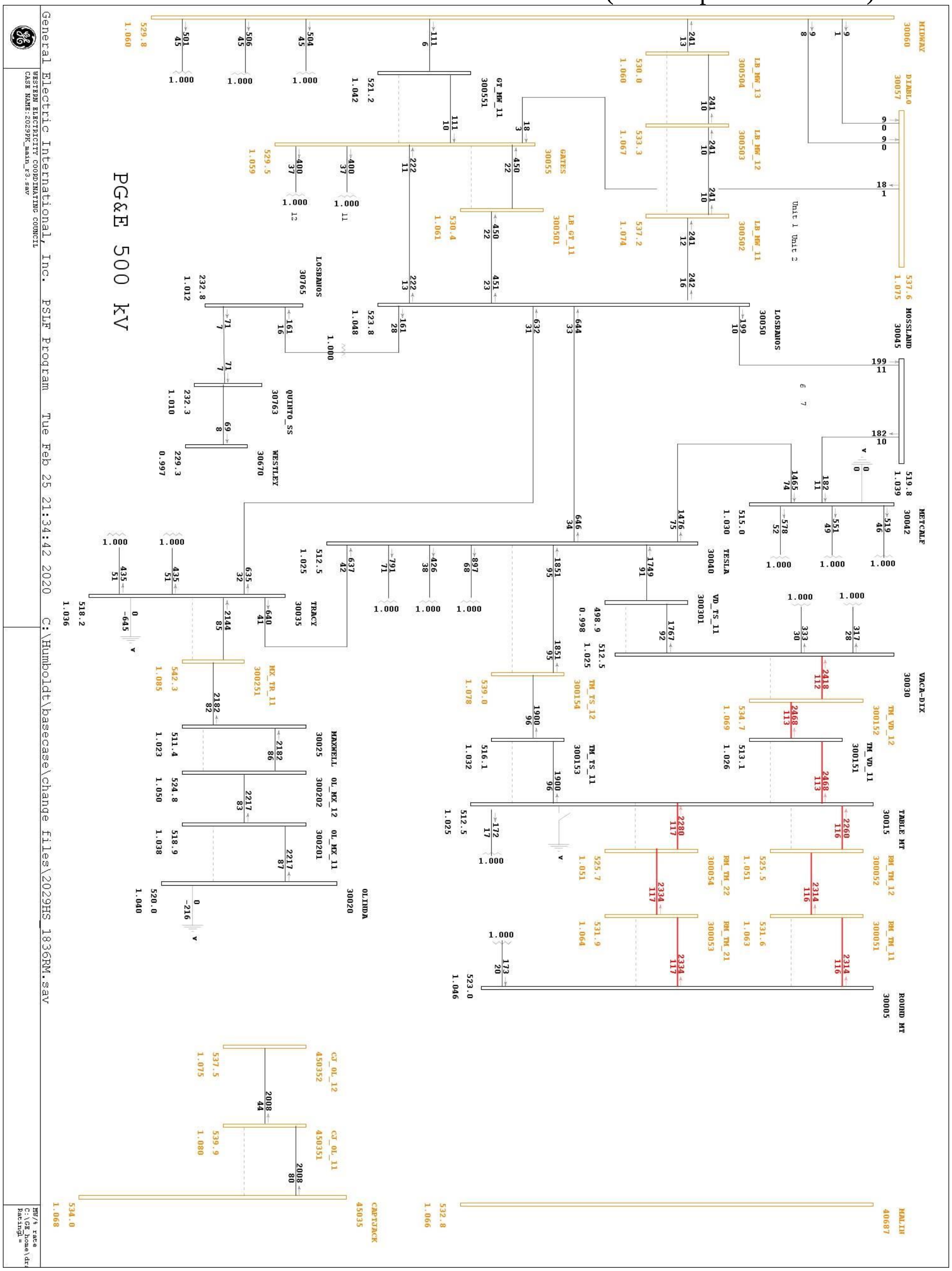


Figure 21 Option 3 connected to Round Mountain 500 kV with no associated upgrades, 2029 Heavy Summer (N-0)

Option 3 Alternative 1

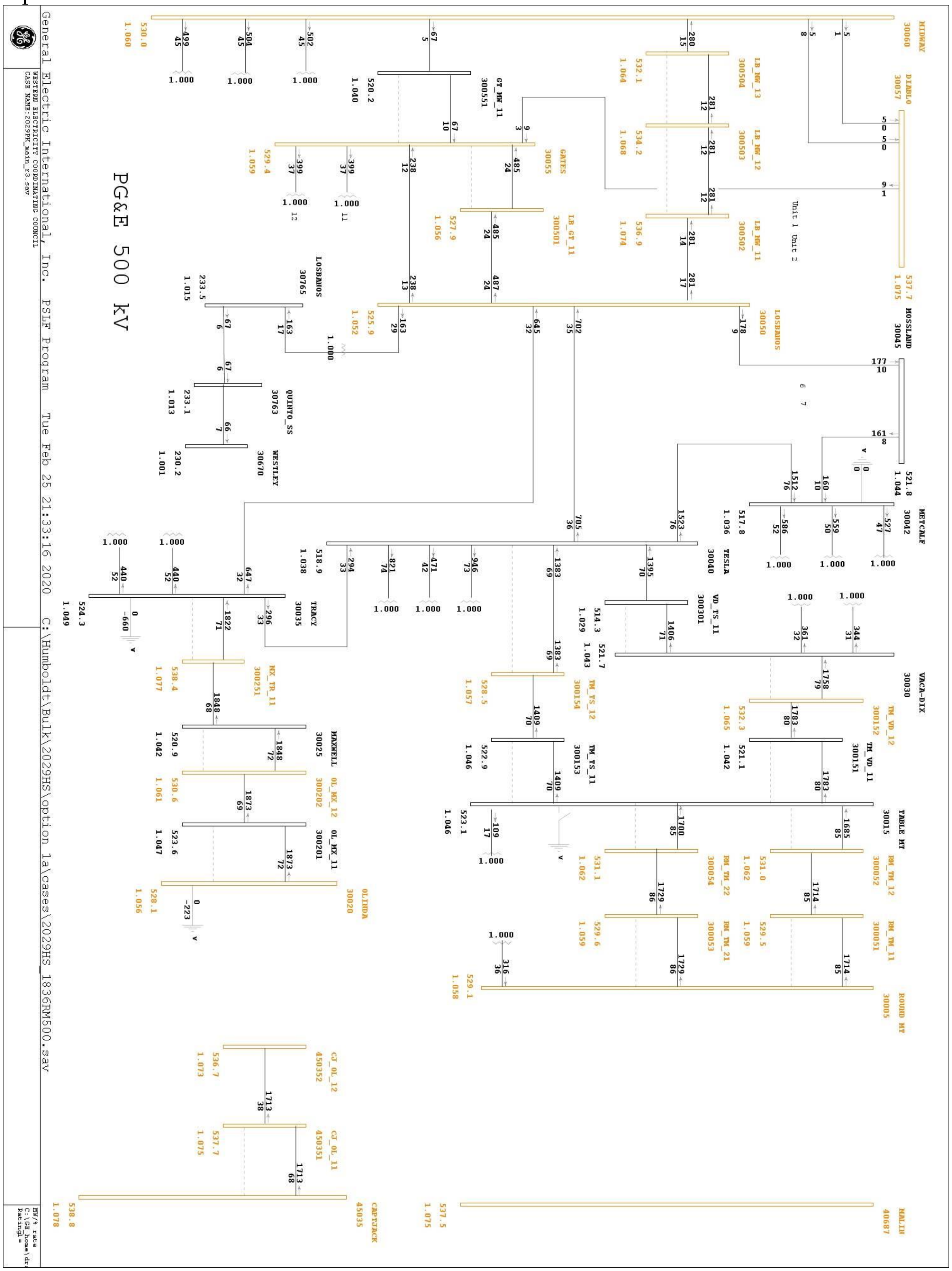


Figure 22 Option 3 Alternative 1 2029 Heavy Summer PSLF Power Flow (N-0)

Generator Modelled with no upgrades modelled: (N-1) Round Mountain – Table Mountain 500 kV Line Out

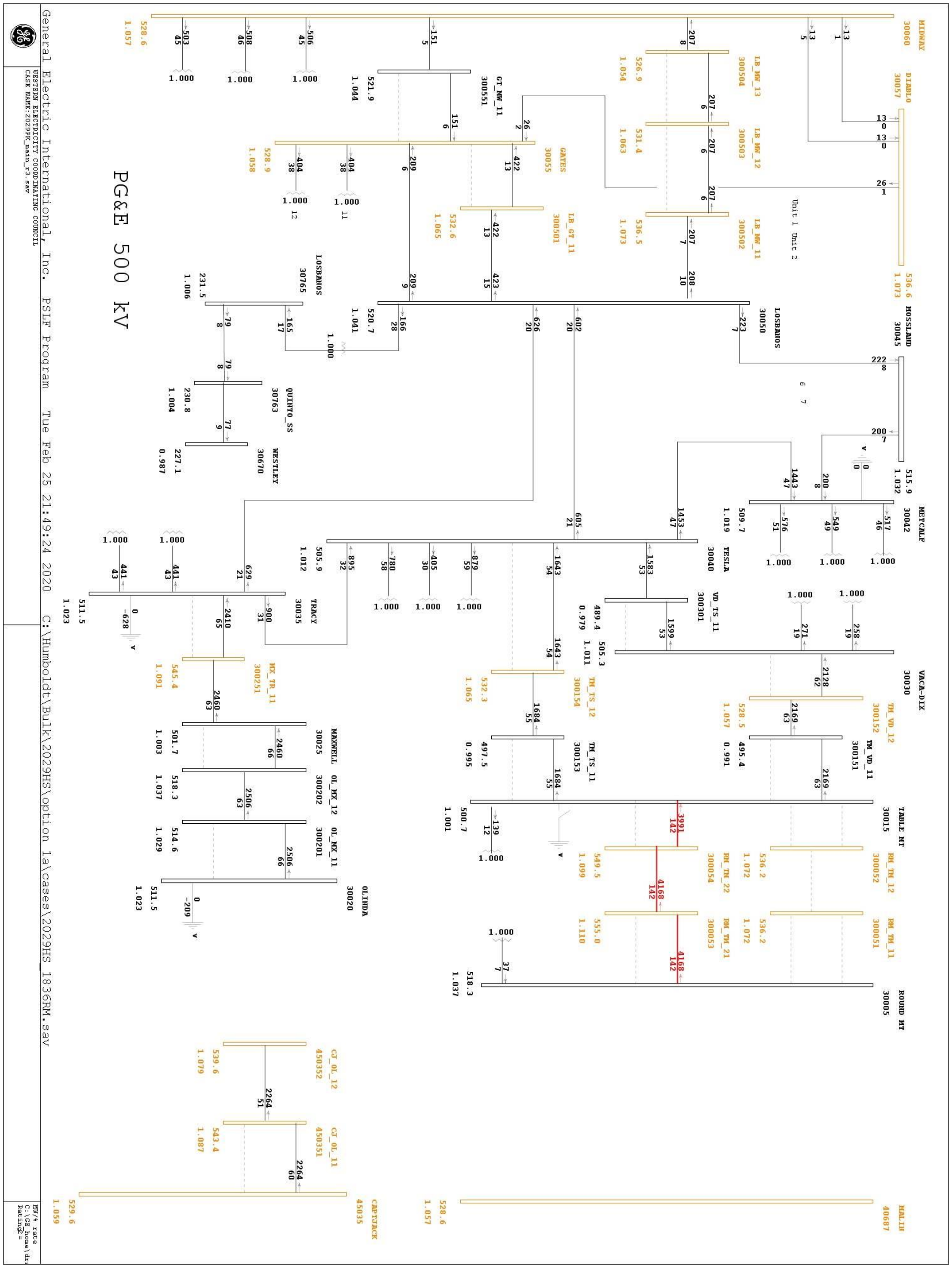


Figure 23 Option 3 connected to Round Mountain 500 kV with no associated upgrades, 2029 Heavy Summer (N-1) Round Mountain – Table Mountain 500 kV line out

Option 3 Alternative 1

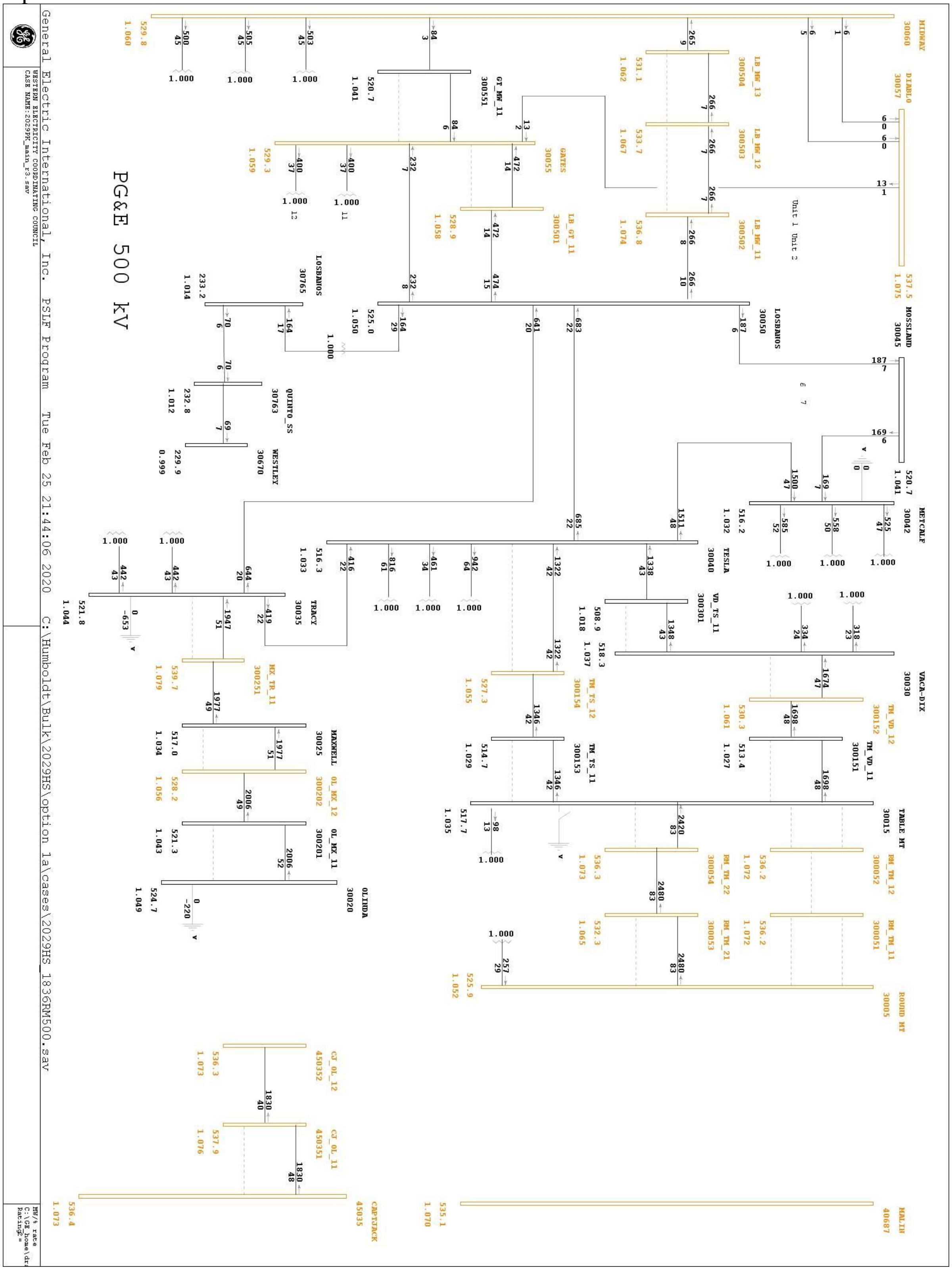


Figure 24 Option 3 Alternative 1 2029 Heavy Summer (N-1) Round Mountain – Table Mountain 500 kV line out

Alternative 2 Background

Alternative 2 consists of interconnecting offshore wind from the Humboldt Coast to Vaca Dixon 500 kV Substation.

The Vaca-Dixon system consists of 230, 115, and 60 kV Lines. Its primary sources include two 500/230 kV Transformers at Vaca-Dixon, four 230 kV lines providing hydro generation via Delevan Substation, two 230 kV lines providing wind generation via Bird's Landing Substation, and local generation. Locally, these sources feed the 115 and 60 kV systems through three Vaca-Dixon 230/115 kV Transformers. This area can be broken up into two major sub-systems: the Vacaville 115 kV pocket and the 60 kV pocket.

The Vacaville 115 kV pocket serves several substations including Vacaville, Suisun, and Jameson, through four 115 kV lines. The 60 kV pocket consists of two Vaca-Dixon 115/60 kV transformers feeding two 60 kV lines.

The southern portion of Solano County has 1,036 MW of wind generation capacity, which is primarily exported to the Greater Bay Area transmission system via two 230 kV lines. The major transmission paths below.

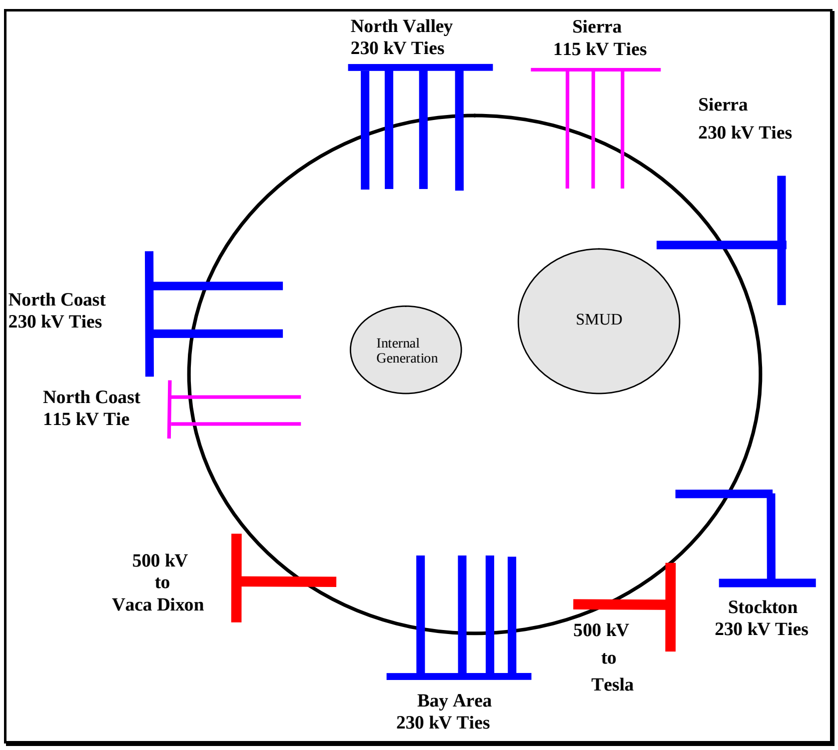


Figure 25 Vaca Dixon Transmission System Connections

As observed above Vaca Dixon sub-transmission system primarily serves the Yolo and Solano Counties. These load centers are currently not as densely populated as the bay area. If an interconnection is terminated at Vaca Dixon 500 kV Substation a route to deliver this power the Bay Area would be recommended.

An option considered is to build a new 500 kV and 230 kV substation to be located in Solano County which would connect to the Vaca Dixon – Tesla 500 kV line. This option would then include building two new 230 kV lines from the new substation to Pittsburg 230 kV Substation which is approximately 5.3 miles in distance. The new 230 kV lines will likely need to cross under the Sacramento River to the East Bay. The new substation connecting to the Vaca Dixon – Tesla 500 kV line along with the 230 kV lines would add a new and diverse source into the area. Resources can be utilized from the northern or southern part of the system giving more flexibility for renewable power to serve Bay Area load.

The Pittsburg area is designed with many 230 kV transmission lines to serve loads in other load pockets in the Bay Area. This particular area is considered the East Bay Planning Division. The East Bay Planning Division, a sub-area of the Greater Bay Area encompasses the East Bay, Diablo, and Mission divisions. This area primarily relies on internal generation to serve electric customers.

Some of the major substations within the East Bay Planning Division are Sobrante, Moraga, Newark, East Shore, San Ramon, Pittsburg, and Contra Costa Substations. The major load centers include the cities along the San Francisco Bay in Alameda and Contra Costa Counties as well as cities in the East Bay hills and Tri-Valley area. The East Bay Planning Division relies on generation and import lines to serve the local demand and exports power to both the SF-Peninsula and South Bay Planning Divisions. Key substations that import power into the East Bay Planning Division are Tesla, Vaca-Dixon, and Metcalf substations, all of which have 500 kV sources. In addition, there are 230 kV transmission facilities from Lakeville and Ignacio Substations that are used to import power from the Geysers geothermal generation in the north and to import from Vaca-Dixon. Generation facilities in the East Bay Planning Division include PG&E's Gateway Generating Station, the Russell City Energy Center (RCEC), and the Marsh Landing Generating Station. Excess internal generation in the East Bay Planning Division is exported to its neighboring areas. The East Bay Planning Division also directly exports approximately 400 MW into San Francisco via the Trans Bay Cable (TBC) under normal operating conditions. The major transmission paths are shown below.

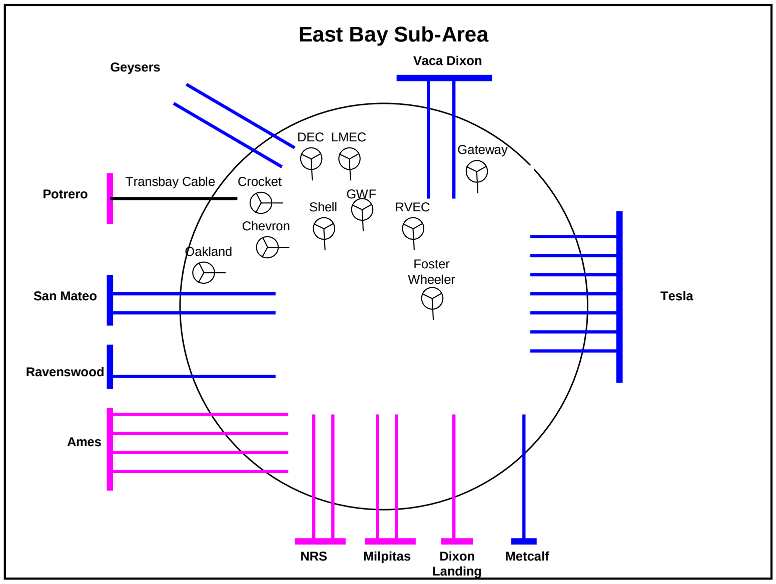


Figure 26 East Bay Transmission System Connection

In the East Bay area dispatch of approximately 4,000 MW is modelled for local area generation.

Alternative 2 Scope

Alternative 2: Build 500 kV Substation and route transmission southeast

- Build 500 kV Transmission Line from 500 kV Substation (to be assumed next to Humboldt Bay 115 kV Substation) to Vaca Dixon 500 kV Substation
- Build new Collinsville 500 kV Substation
- Loop Vaca Dixon-Tesla 500 kV line into new station
- Reconductor 25 miles of the Vaca Dixon-Collinsville 500 kV Line
- Install 500/230 kV transformer at new station
- Construct two, 5.3-mile subsea 230 kV cables to Pittsburg P.P. Substation
- Install voltage support as required at various locations with the Bay Area

Associated Substation reconfigurations and upgrades at substations not to be assumed in this study. Acquiring land and permitting will also not be included in this study

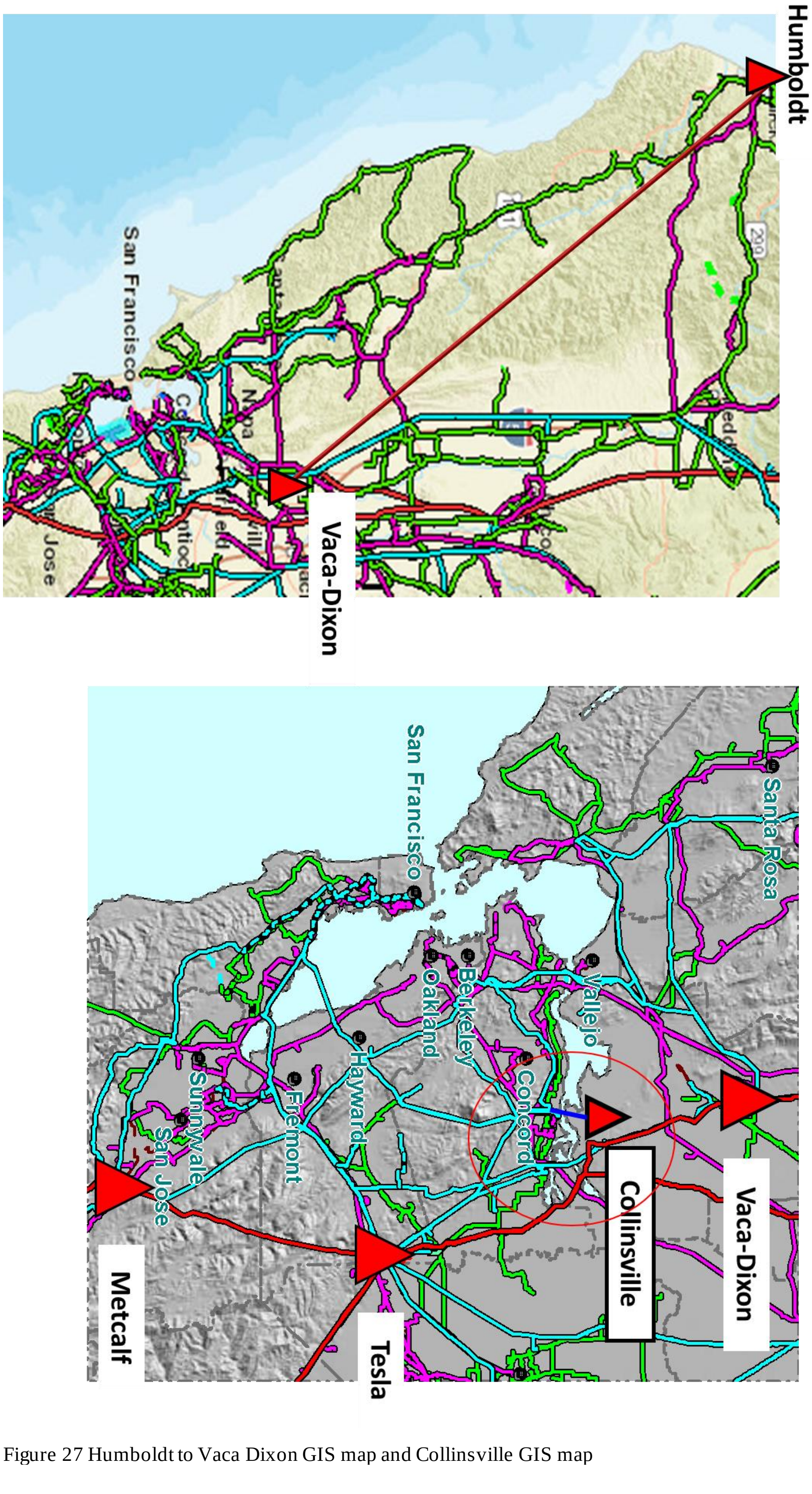


Figure 27 Humboldt to Vaca Dixon GIS map and Collinsville GIS map

Capacity and Reliability Review

Planning assessment has identified a potential thermal overload in 2029 under peak loading conditions for normal conditions. During normal conditions the Vaca Dixon - Collinsville 500 kV line could potentially load up to 131% of its normal summer conductor ratings. The table below shows a summary of the thermal loading with respect to the worse contingencies.

Table 12 Option 3 Alternative 2 Line Loading Summary

Transmission Line	Pre - Project Loading (normal rating)	Post - Project Loading (normal rating)
Vaca Dixon - Collinsville 500 kV Line	66% (VD - Tesla)	131%

With the current configuration, additional generation connected to the Vaca Dixon 500 kV/Collinsville 500 kV Substations is not feasible as status quo. The additional generation injected into the substations causes overloads on the Vaca Dixon – Collinsville 500 kV Line. This Vaca Dixon – Tesla 500 kV Line is looped into Collinsville. The portion of line between Vaca Dixon and Collinsville overload due to the added generation at the Vaca Dixon bus. Reconductoring of this portion of the line would be recommended to withstand normal operating conditions.

Evaluation of Alternative

A power flow contingency analysis was performed using the 2029 base cases against all the Category P1 (L-1, T-1, G-1), P7 and selected P6 contingencies within the study area. The results were then screened for any thermal overloads or voltage violations along with any non converging cases or excessive voltage mismatches. For this power flow analysis all base cases converged.

The table below shows the power flow analysis results.

Table 13 Power Flow Results for Option 3 Alternative 2

NERC	Facility Name	BasekV	Contingency Name	Rating	2029H SOP2	2029SP OPop2	Corrective Action Plan
P0	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500.0	System Normal	2230.0A	130.8%	>95%	reconductor
P0	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	System Normal	2230.0A	131.0%	>95%	reconductor
P1-2	ROUND MT 230kV-ROUND MT 500kV ckt=1	230/500	Captain Jack - Olinda #1 500kV Line	1122.0MVA	>95%	105.2%	existing issue
P1-2	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500.0	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line	3555.9A	102.7%	>95%	reconductor
P1-2	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line	3555.9A	102.7%	>95%	reconductor
P1-3	BRIGHTON 230kV-LOCKJ1 230kV ckt=1	230.0	Table Mountain 230/500kV Bank #1	850.0A	>95%	111.8%	existing issue
P1-3	EIGHT MI 230kV-TESLA E 230kV ckt=1	230	Table Mountain 230/500kV Bank #1	928.0A	>95%	127.9%	existing issue
P1-3	GOLDHILL 230kV-EIGHT MI 230kV ckt=1	230.0	Table Mountain 230/500kV Bank #1	975.0A	>95%	104.2%	existing issue

NERC	Facility Name	BasekV	Contingency Name	Rating	2029H SOP2	2029SP OPop2	Corrective Action Plan
P1-3	GOLDHILL 230kV-LODI 230kV ckt=1	230	Table Mountain 230/500kV Bank #1	964.9A	>95%	104.7%	existing issue
P1-3	OLINDA 500kV-OLINDAW 230kV ckt=1	500/230	ROUND MT 230/500kV Bank #1	1041.0MVA	>95%	107.7%	existing issue
P1-3	OLINDAW 230kV-KE_SOUTH 230kV ckt=1	230.0	ROUND MT 230/500kV Bank #1	810.8A	>95%	100.9%	existing issue
P1-3	RIO OSO 230kV-LOCKFORD 230kV ckt=1	230.0	Table Mountain 230/500kV Bank #1	800.0A	>95%	103.1%	existing issue
P1-3	ROUND MT 230kV-ROUND MT 500kV ckt=1	230/500	OLINDA 500/230kV Bank #1	1122.0MVA	>95%	103.9%	existing issue
P6-1_1	CAYETANO 230kV-NDUBLIN 230kV ckt=1	227.0	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	1004.1A	102.1%	>95%	reduce generation
P6-1_1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	228.0	TESLA-METCALF #1 500kV Line & METCALF-MOSSLAND #1 500kV Line	1005.1A	100.4%	>95%	reduce generation
P6-1_1	CAYETANO 230kV-USWP-JRW 230kV ckt=1	229.0	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	1005.1A	103.0%	>95%	reduce generation
P6-1_1	NEWARK E 230kV-NWK DIST 230kV ckt=1	230.0	TESLA-METCALF #1 500kV Line & MOSSLAND-LOSBANOS #1 500kV Line	2339.5A	102.6%	>95%	reduce generation
P6-1_1	OLINDA 500kV-OLINDAW 230kV ckt=1	500/230	Malin - Round Mountain #1 500kV Line & Malin - Round Mountain #2 500kV Line & Round Mountain - Table Mountain #2 500kV Line	1041.0MVA	>95%	128.9%	reduce generation
P6-1_1	OLINDAW 230kV-KE_SOUTH 230kV ckt=1	230.0	Malin - Round Mountain #1 500kV Line & Malin - Round Mountain #2 500kV Line & Round Mountain - Table Mountain #2 500kV Line	810.8A	>95%	115.5%	reduce generation
P6-1_1	ROUND MT 230kV-ROUND MT 500kV ckt=1	230/500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	1122.0MVA	>95%	113.8%	reduce generation
P6-1_1	ROUND MT 230kV-ROUND MT 500kV ckt=1	230/500	Round Mountain - Table Mountain #2 500kV Line & Malin - Round Mountain #2 500kV Line & Round Mountain - Table Mountain #1 500kV Line	1122.0MVA	>95%	110.8%	reduce generation
P6-1_1	ROUND MT 230kV-ROUND MT 500kV ckt=1	230/500	Round Mountain - Table Mountain #2 500kV Line & Round Mountain - Table Mountain #1 500kV Line & Malin - Round Mountain #1 500kV Line	1122.0MVA	>95%	111.5%	reduce generation
P6-1_1	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3555.9A	103.0%	>95%	reconductor
P6-1_1	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3555.9A	102.4%	>95%	reconductor
P6-1_1	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3555.9A	102.0%	>95%	reconductor
P6-1_1	VACA-DIX 500kV-VD_CV_11 500kV ckt=1	500	Table Mountain - Tesla #1 500kV Line & TRACY-TESLA #1 500kV Line	3555.9A	106.1%	>95%	reconductor
P6-1_1	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & Captain Jack - Olinda #1 500kV Line	3555.9A	103.1%	>95%	reconductor
P6-1_1	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-LOSBANOS #1 500kV Line	3555.9A	102.5%	>95%	reconductor
P6-1_1	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	Olinda - Maxwell #1 500kV Line & Maxwell - Tracy #1 500kV Line & TRACY-TESLA #1 500kV Line	3555.9A	102.1%	>95%	reconductor
P6-1_1	VD_CV_11 500kV-COLLNSVL 500kV ckt=1	500	Table Mountain - Tesla #1 500kV Line & TRACY-TESLA #1 500kV Line	3555.9A	106.2%	>95%	reconductor

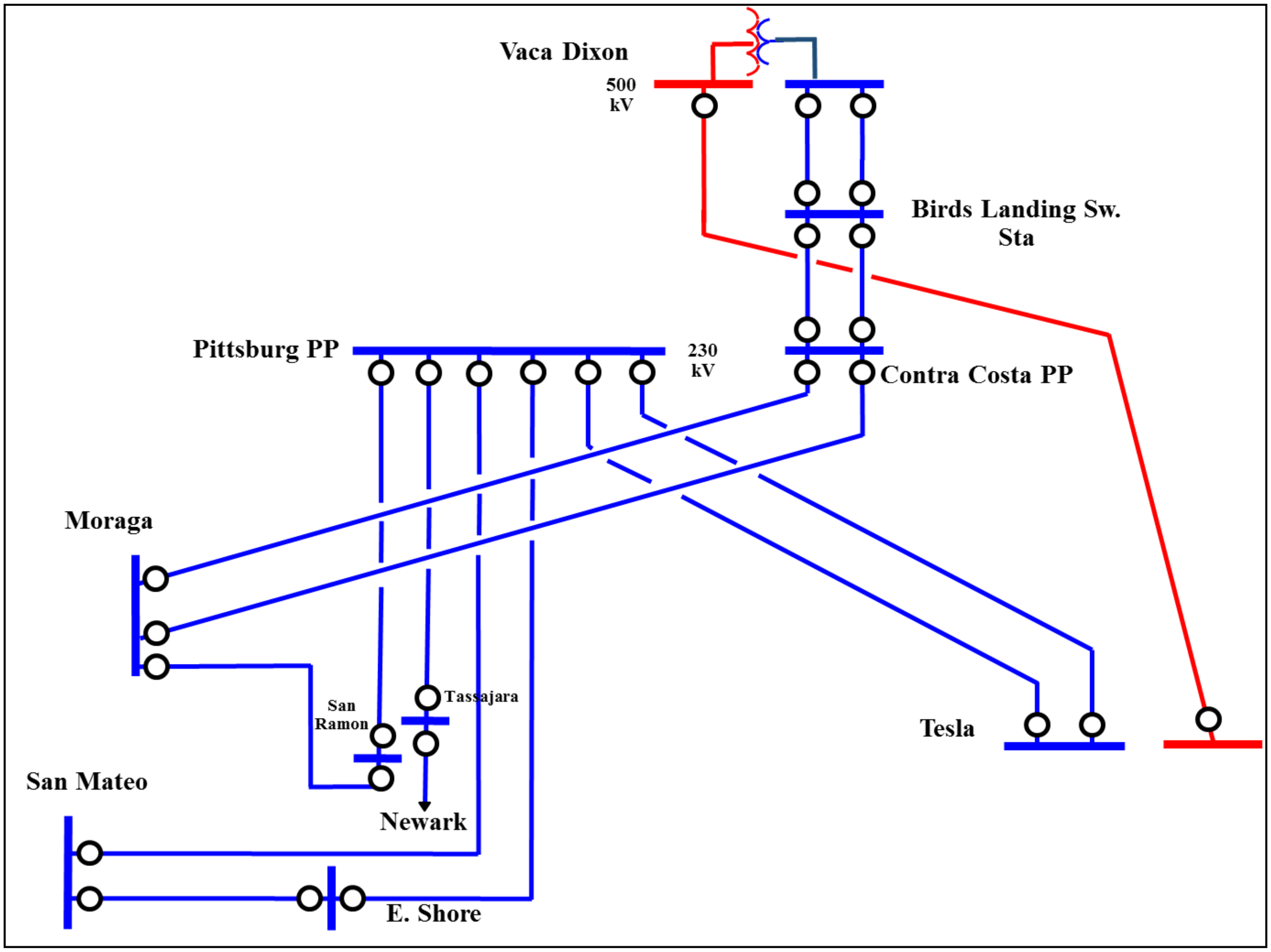


Figure 28 Status Quo East Bay 230 kV Single Line Diagram

Build new Collinsville Substation

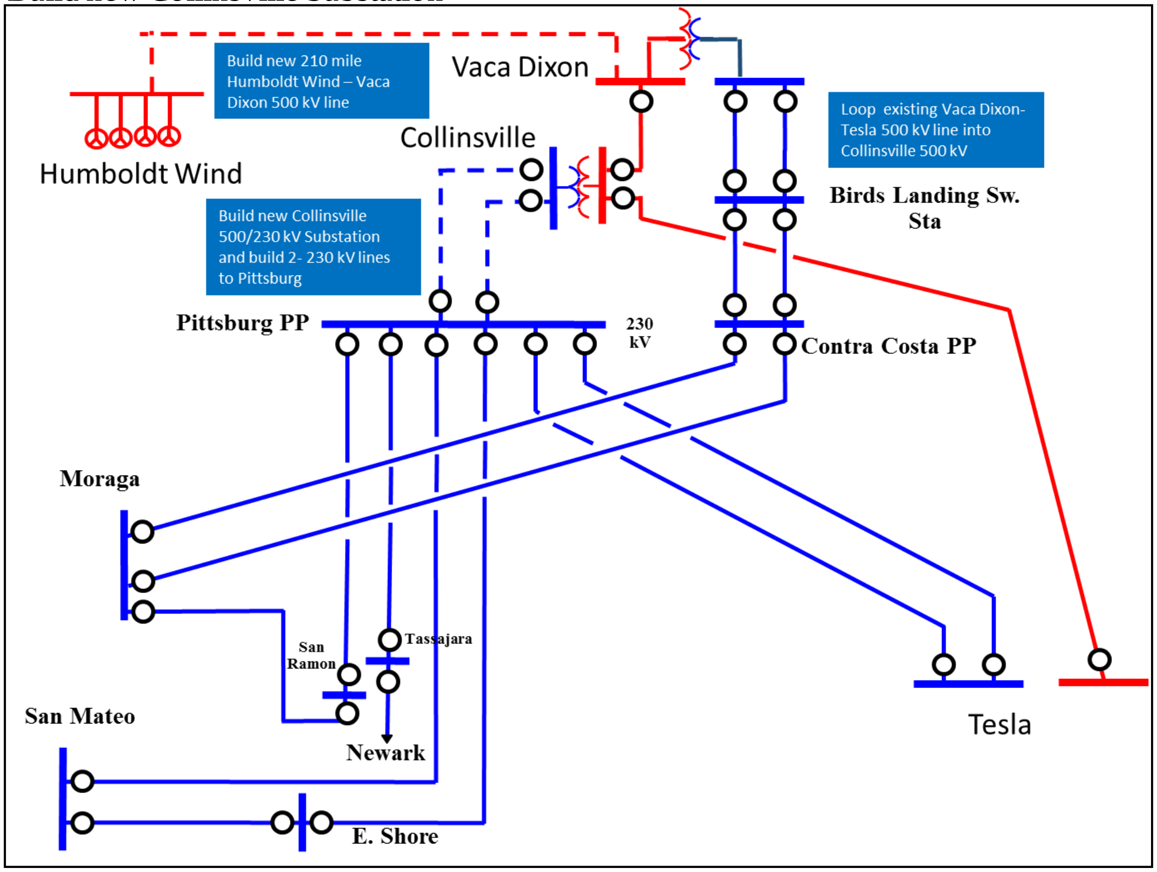


Figure 29 Option 3 Alternative 2 Single Line Diagram

Normal Condition (N-0)

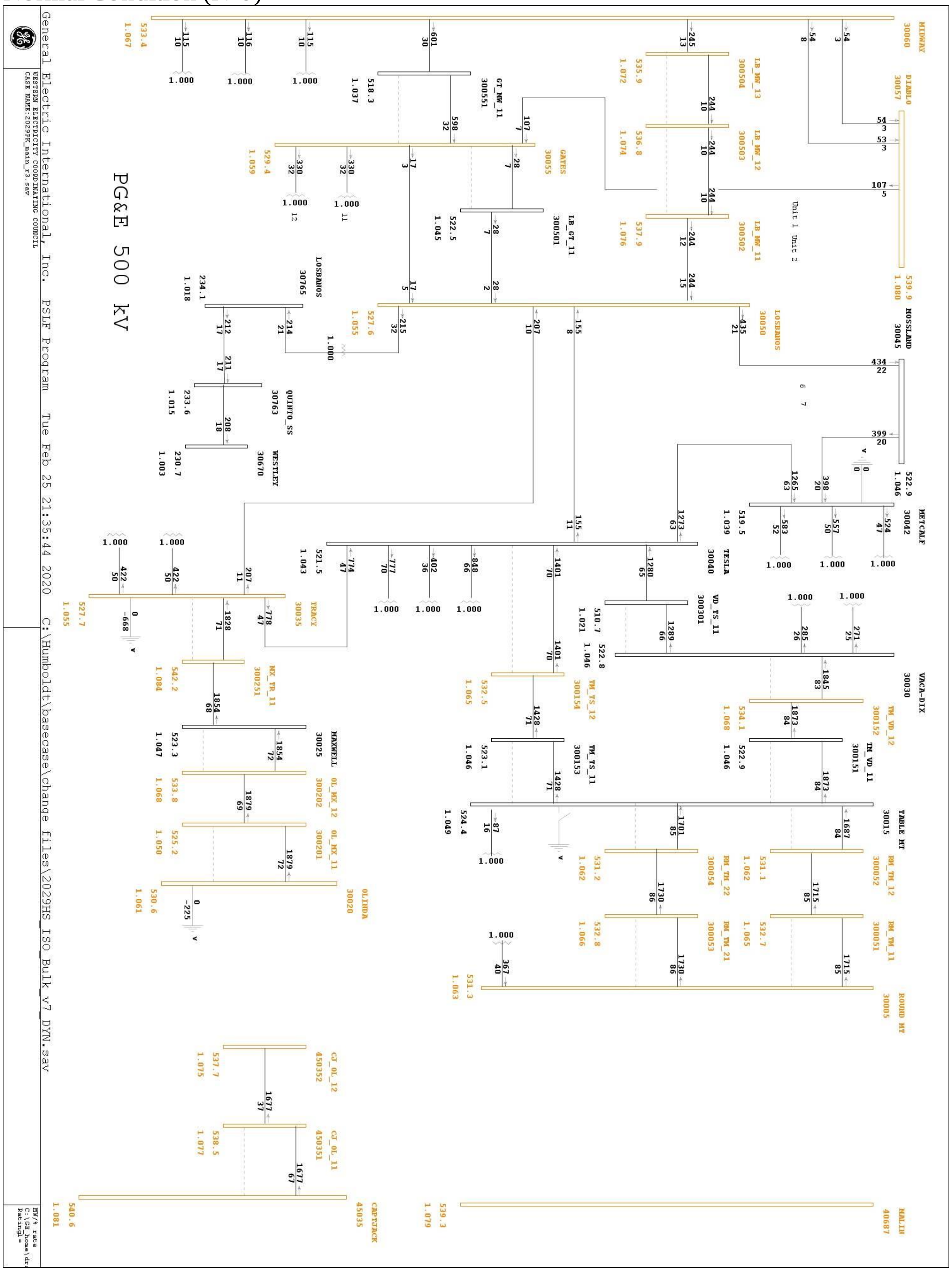


Figure 30 Status Quo 2029 Heavy Summer PSLF Power Flow (N-0)

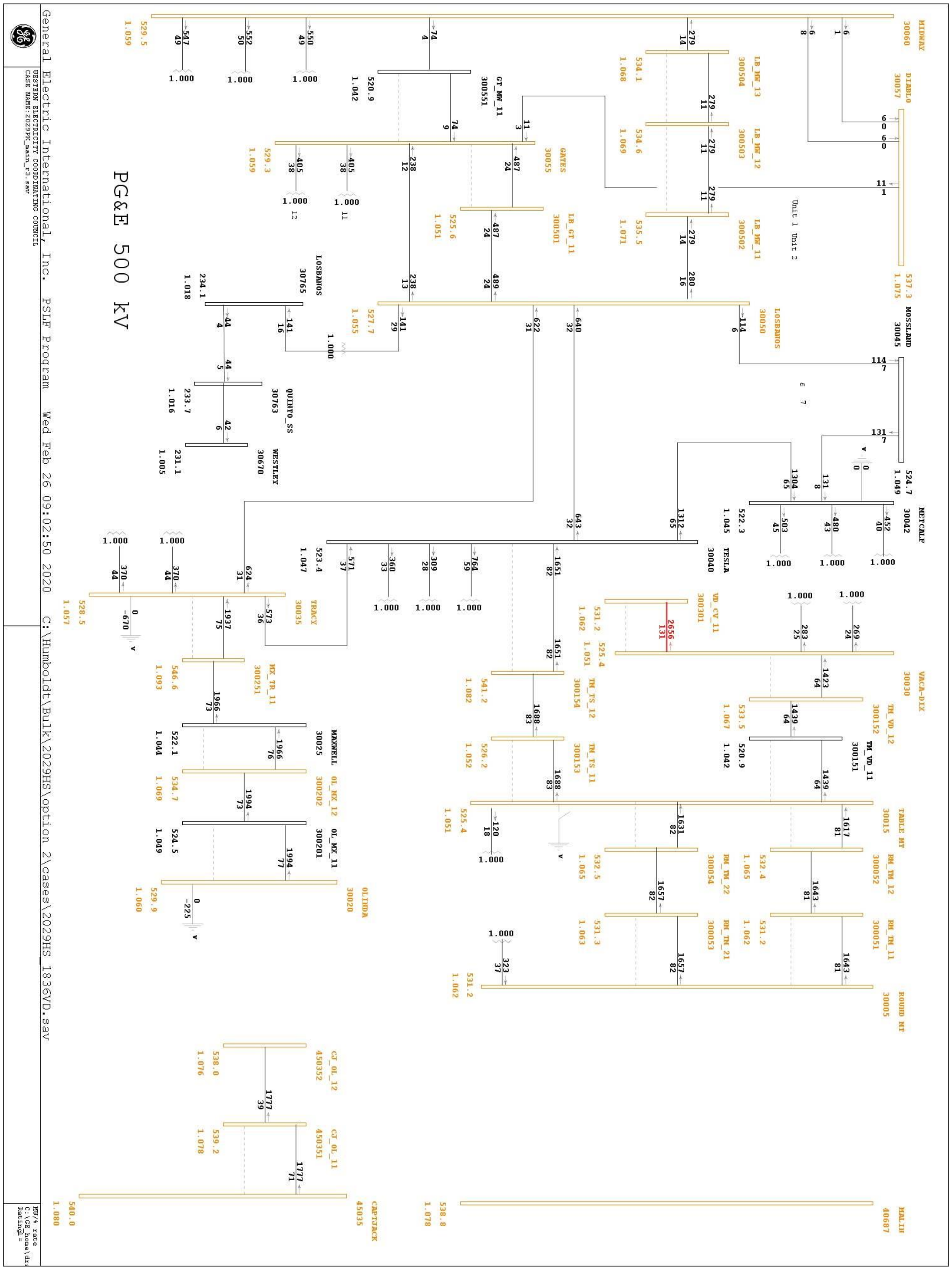


Figure 31 Option 2 connected to Vaca Dixon with new Collinsville connection (no other associated upgrades modelled) (N-0)

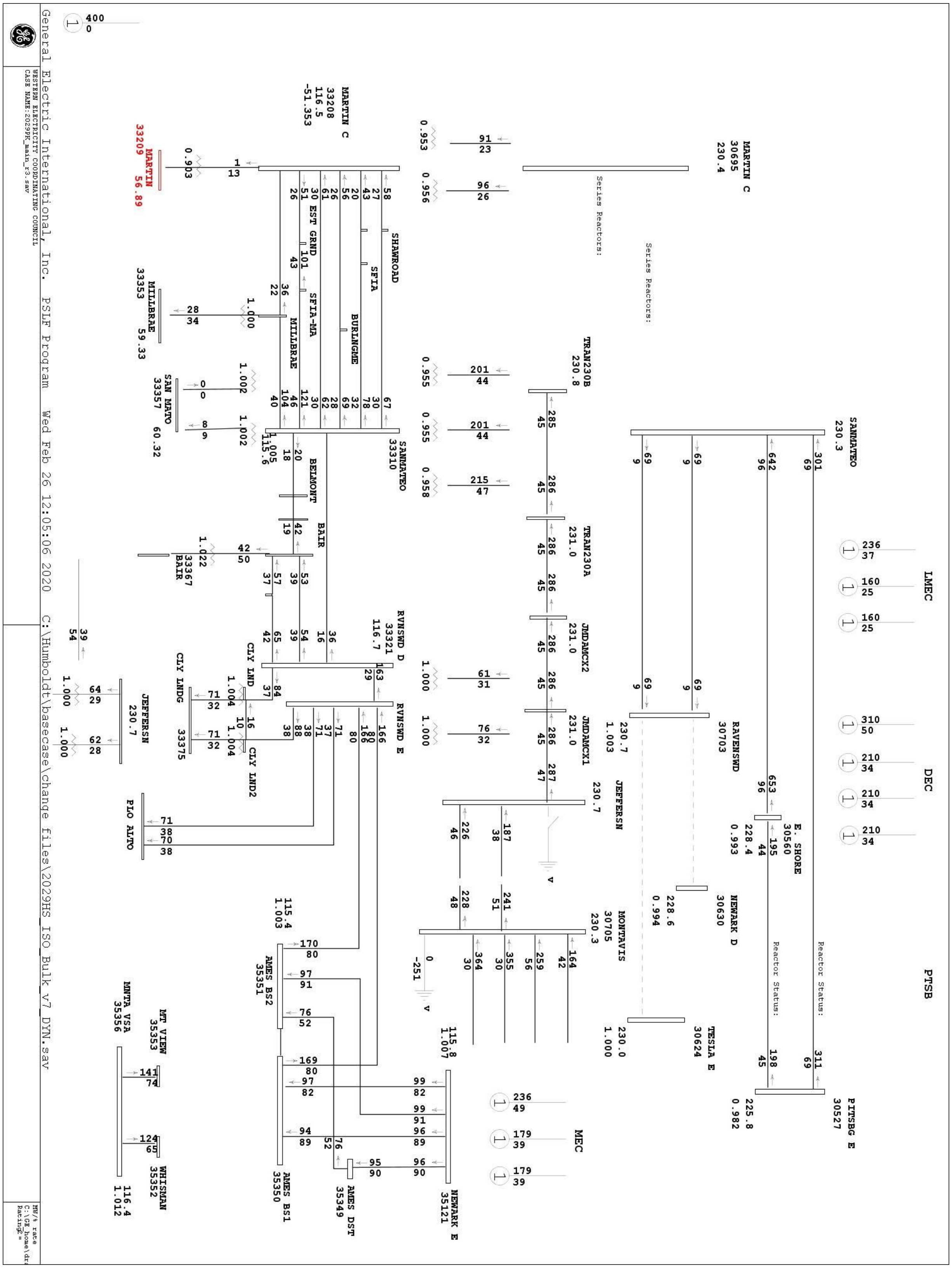


Figure 32 Status Quo 2029 Heavy Summer PSLF Power Flow (N-2) Newark – Ravenswood and Tesla – Ravenswood 230 kV Line Out

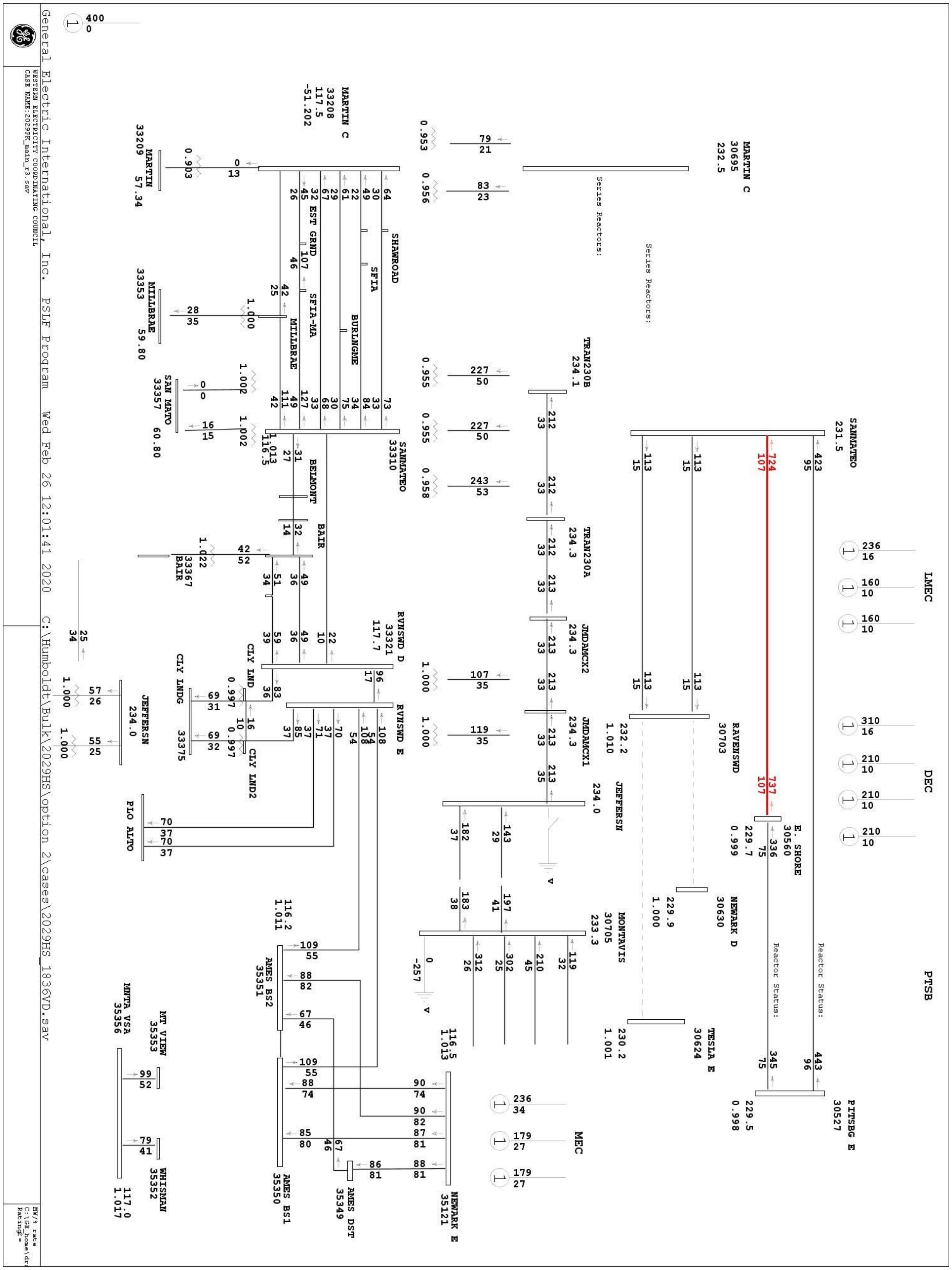


Figure 33 Option 2 connected to Vaca Dixon with new Collinsville connection and no other associated upgrades with DCTL Newark – Ravenswood and Tesla – Ravenswood 230 kV lines out

Alternative 3 Background

PG&E studied the interconnection of 1,836 MW of offshore wind connected from the Humboldt Coast to the Bay Area. There is no single sub-transmission substation that could withstand an injection of 1,836 MW's. Therefore, power was distributed to three points of connection 1) Potrero located in the SF Peninsula 2) Los Esteros located in the South Bay and 3) East Shore located in the East Bay. The San Francisco-Peninsula Planning Division ("SF-Peninsula"), is composed of cities in San Francisco and San Mateo Counties. The major cities in SF-Peninsula are San Francisco, San Bruno, San Mateo, Redwood City, and Palo Alto. While the SF-Peninsula has some small generation facilities, the area relies almost exclusively on transmission line imports to serve its electric demand. Power is imported into SF-Peninsula from Pittsburg, East Shore, Tesla, Newark, Monte Vista, and Ames substations located in the Greater Bay Area's East Bay and South Bay Planning Divisions. The amount and location of transmission import is dependent on electric demand and generation dispatched within the Greater Bay Area. The major SF-Peninsula transmission paths below.

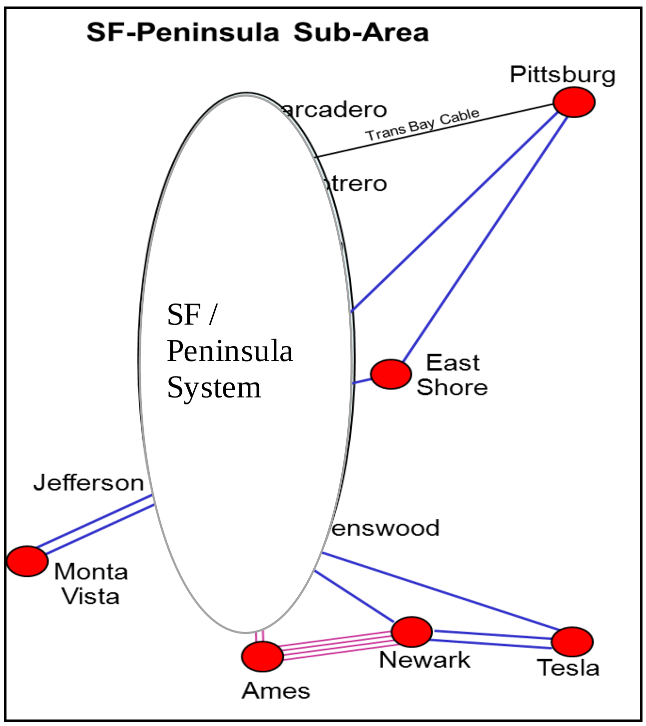


Figure 34 San Francisco Peninsula Transmission System connection

SF-Peninsula relies heavily on import lines to serve local demand because no large-scale generation is located within the area. The San Francisco System includes 230 kV and 115 kV transmission facilities with all transmission lines installed underground and utilizes gas-insulated switchgear at these facilities in much higher concentration than other PG&E areas. The system receives power through eight lines into Martin Substation and the Trans Bay Cable (TBC) into Potrero Substation. The San Francisco-Peninsula Planning Division modeled a generation dispatch of around 12 MW.

The South Bay Planning Division ("South Bay"), a sub-area of the Greater Bay Area, encompasses the De Anza and San Jose divisions and the City of Santa Clara (Silicon Valley Power, or SVP). Some of the key substations that deliver power into or in South Bay are Metcalf, Newark, Monta Vista, and Los Esteros Substations. Major cities in the area include San Jose, Santa Clara, Mountain View, Morgan Hill, and Gilroy. Major internal generation in the South Bay includes Calpine's Metcalf Energy Center, Los Esteros Critical Energy Facility, and Gilroy Units; and SVP's Donald Von Raesfeld Power Plant. South Bay is home to many large load customers such as Google, Facebook, Apple, Salesforce, Cisco Systems and Agilent Technologies to name a few.

The major transmission paths are illustrated below.

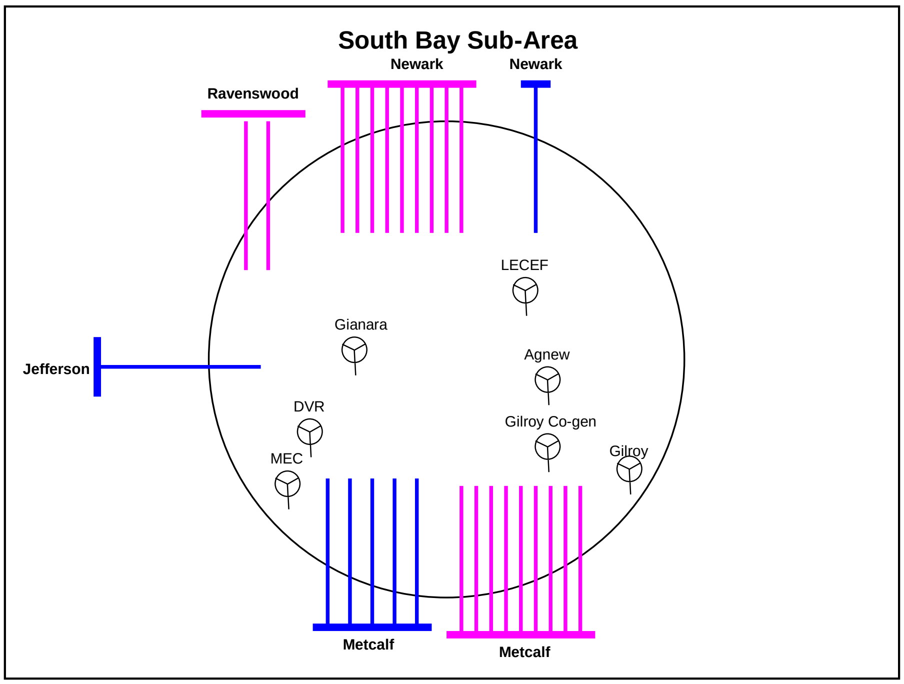


Figure 35 South Bay Transmission System connections

The East Bay Planning Division, a sub-area of the Greater Bay Area that encompasses the East Bay, Diablo, and Mission divisions, is composed of cities in Alameda and Contra Costa Counties. Major cities in the East Bay Planning Division include Oakland, Berkeley, Hayward, Fremont, San Ramon, Dublin, Pleasanton, Concord, Pittsburg, and Antioch. This area primarily relies on internal generation to serve electric customers. Some of the major substations within the East Bay Planning Division are Sobrante, Moraga, Newark, East Shore, San Ramon, Pittsburg, and Contra Costa Substations. The major load centers include the cities along the San Francisco Bay in Alameda and Contra Costa Counties as well as cities in the East Bay hills and Tri-Valley area. The East Bay Planning Division relies on generation and import lines to serve the local demand and exports power to both the SF-Peninsula and South Bay Planning Divisions. Key substations that import power into the East Bay Planning Division are Tesla, Vaca-Dixon, and Metcalf substations, all of which have 500 kV sources. In addition, there are 230 kV transmission facilities from Lakeville and Ignacio Substations that are used to import power from the Geysers geothermal generation in the north and to import from Vaca-Dixon. Generation facilities in the East Bay Planning Division include PG&E's Gateway Generating Station, the Russell City Energy Center (RCEC), and the Marsh Landing Generating Station. Excess internal generation in the East Bay Planning Division is exported to its neighboring areas primarily the South Bay and Peninsula. In addition to generation in the East Bay Planning Division, there are transmission interconnections to Tesla Substation, Vaca-Dixon Substation and the wind resources to the south of Vaca-Dixon, and geothermal generation from the Geysers generation units to the north. The East Bay Planning Division also directly exports approximately 400 MW into San Francisco via the Trans Bay Cable (TBC) under normal operating conditions. The major transmission paths are illustrated below.

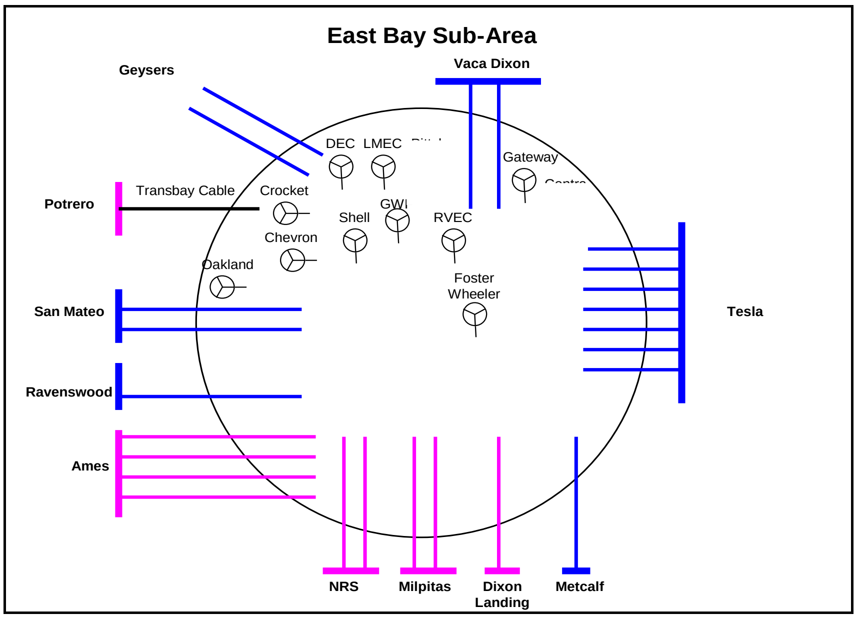


Figure 36 East Bay Electric Transmission connections

The East Bay Planning Division assessment modeled a dispatch of approximately 4,000 MW for local area generation. The East Shore Substation is located in the City of Hayward (Mission division) and serves as a 230kV source for the local 115 kV system, including Grant, Mt. Eden, and Dumbarton Substations. At the same time, East Shore is connected with Pittsburg, San Mateo and Russell City Energy Center (RCEC) so that it can deliver power to the Peninsula area via the East Shore-San Mateo 230 kV line and serve local load via transformer banks #1 and #2. In addition to East Shores ties to the Peninsula. The South Oakland sub-system includes 115 kV transmission facilities extending from Moraga and East Shore Substations. Three 115 kV lines serve San Leandro Substation and two lines serve Oakland J Substation. The East Shore-Oakland J 115 kV Reconductoring Project, scheduled to be operational in 2022, will reconductor a normally open path from the south, providing a third and a diverse source into Oakland J. With this project, capacity constraints on PG&E's system are alleviated, eliminating the need to drop load at Oakland Station J for an N-1 contingency. With the East Shore-Oakland J 115 kV Reconductoring Project, East Shore Substation becomes a strong source for the Oakland area.

Alternative 3: Build 500 kV transmission line from Humboldt area to Bay Area

- Build new 275 mile Humboldt Wind - BayHub 500 kV Line
- Build new Bay Hub 500/230 kV Substation
- Build 3-230 kV HVDC subsea cables
  1) Bay Hub - Potrero No. 1 230 kV Line
  2) Bay Hub - E. Shore No. 1 230 kV Line
  3) Bay Hub - Los Esteros No. 1 230 kV Line
- Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line

Associated Substation reconfigurations and upgrades at substations not to be assumed in this study. Acquiring land and permitting will also not be included in this study

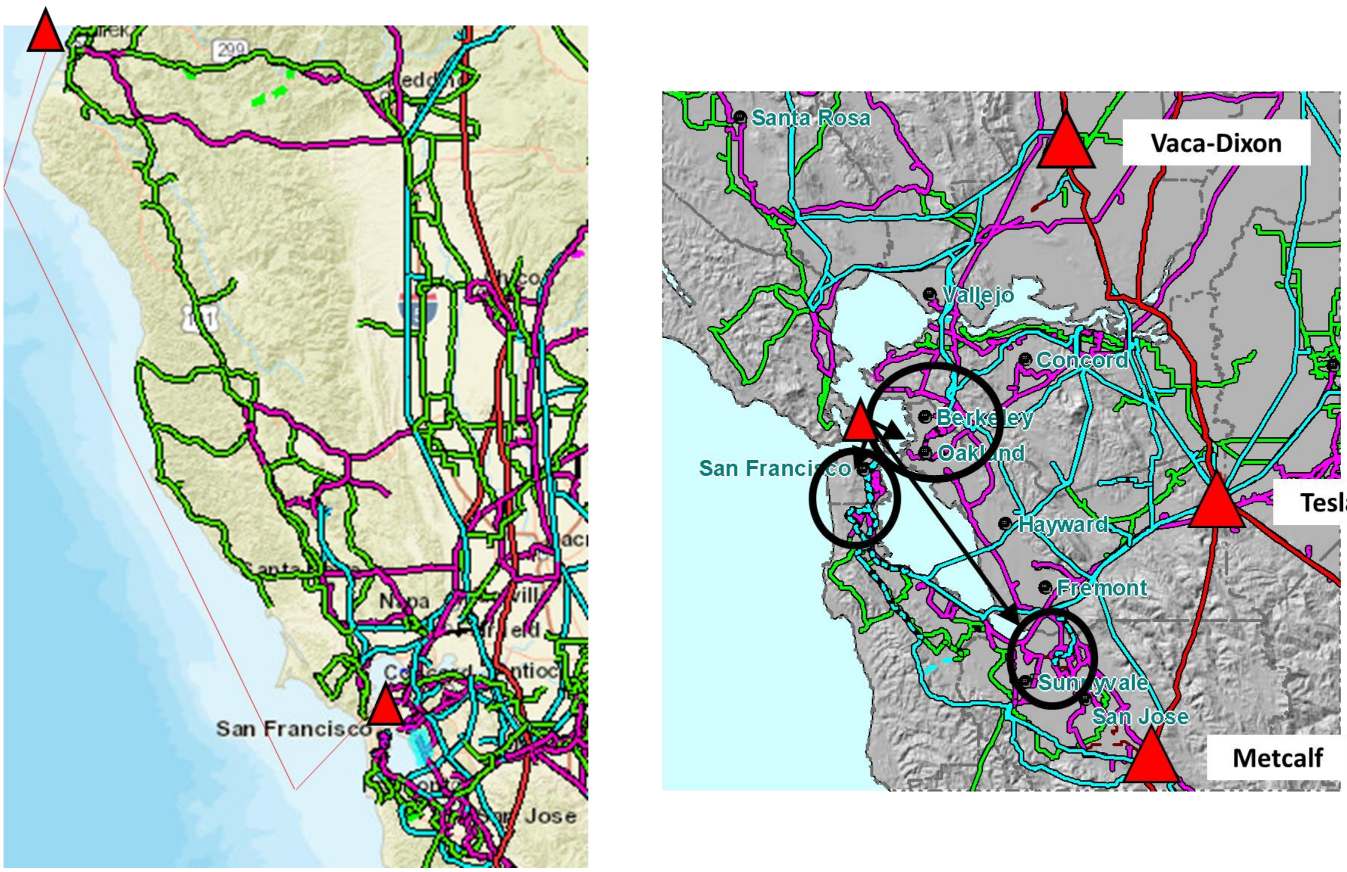


Figure 37 Humboldt to Bay Area GIS map and Bay Area GIS map

Capacity and Reliability Review

Planning assessment has identified a potential thermal overload in 2029 under peak loading conditions for emergency conditions. During various P1 and P7 contingency conditions the various transmission lines located within the SF Peninsula overload. The lines could potentially load up to 170% of its emergency summer conductor ratings. The table below shows a summary of the thermal loading with respect to the worse contingencies.

Table 14 Option 3 Alternative 3 Line Loading Summary

Transmission Line	Pre - Project Loading (emergency rating)	Post - Project Loading (emergency rating)
POTRERO-PTR_SHUNT-EMBARCADERO 230 kV	24%	131%
POTRERO – MISSON 115 kV	64%	120%
EMBARCADERO-MARTIN 230 kV	71%	170%
POTRERO 230/115 kV transformer	32%	174%
SANMATEO to BELMONT 115 kV	88%	106%
PITSBURG to CLAYTON 115 kV	98%	100%

With the current configuration, additional generation connected to the Bay Area Substations is not feasible as status quo. The additional generation injected into the substations causes overloads for many transmission lines. This is observed when the power flow from Bay Hub 230 kV to the load serving substations is not controlled. It is recommended to either install phase shifters or allocate DC transmission lines to control power flow. If power flow is not distributed in a controlled manner the distribution of generation will favor Potrero Substation. In the study it was observed from the 1836 MW's installed the Potrero Substation injected 1182 MW's, Los Esteros injected 369 MW and East Shore injected 197 MW's. With the large imports into the Potrero Substation the excess power then overloaded many of the lines interconnected within the SF Peninsula. If total MW of injection is reduced to around 1300MW's and distributed optimally this study shows that there will be no P1 or P7 violations.

Evaluation of Alternative

A power flow contingency analysis was performed using the 2029 base cases against all the Category P1 (L-1, T-1, G-1), P7 and selected P6 contingencies within the study area. The results were then screened for any thermal overloads or voltage violations along with any non converging cases or excessive voltage mismatches. For this power flow analysis all base cases converged.

The table below shows the power flow analysis results.

Table 15 Power Flow Results for Option 3 Alternative 3

NERC	Facility Name	BaseKV	Contingency	Rating (N/E)	2029HS	2029HS BAY	2029SP OPBAY	Corrective Action Plan
P1-2	33204 POTRERO 115 30698 POTRERO 230 1 1	115/230	P1-2:A9:1:_EMBRCDRD-POTRERO 230kV [0]	462 MVA (E)	>95%	173.9%	125.9%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30685 EMBRCDRD 230 2	230	P1-2:A9:2:_EMBRCDRD-EGBERT 230kV [0]	1050 Amps (E)	>95%	170.1%	123.2%	allocate power flow via DC controllable injection

NERC	Facility Name	BaseKV	Contingency	Rating (N/E)	2029HS	2029HS BAY	2029SP OPBAY	Corrective Action Plan
	1							
P1-2	30689 MARTN S5 230 30695 MARTIN C 230 1 1	230	P1-2:A9:2:_EMBRCDRD-EGBERT 230kV [0]	1050 Amps (E)	>95%	161.4%	124.2%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P1-2:A9:6:_EGBERT-MARTIN C 230kV [0]	1050 Amps (E)	>95%	138.8%	95.9%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30695 MARTIN C 230 1 1	230	P1-2:A9:6:_EGBERT-MARTIN C 230kV [0]	1050 Amps (E)	>95%	130.4%	96.9%	allocate power flow via DC controllable injection
P1-2	30694 MARTN S4 230 30695 MARTIN C 230 1 1	230	P1-2:A9:5:_EMBRCDRD-MARTIN C 230kV [0]	1050 Amps (E)	>95%	124.6%	90.4%	allocate power flow via DC controllable injection
P1-3	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P1-3:A9:3:_POTRERO 230/115kV TB 1	1050 Amps (E)	>95%	124.1%	85.1%	allocate power flow via DC controllable injection
P1-2	33203 MISSON 115 33204 POTRERO 115 1 1	115	P1-2:A9:1:_EMBRCDRD-POTRERO 230kV [0]	788 Amps (E)	>95%	120%	96%	allocate power flow via DC controllable injection
P1-3	30689 MARTN S5 230 30695 MARTIN C 230 1 1	230	P1-3:A9:3:_POTRERO 230/115kV TB 1	1050 Amps (E)	>95%	117.8%	85.5%	allocate power flow via DC controllable injection
P7-1	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P7-1:A10:1_Eastshore-San Mateo 230 kV and Pittsburg-San Mateo 230 kV lines	1050 Amps (E)	>95%	114.3%	70.2%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P1-2:A16:10:_EASTSHORE-SAN MATEO 230kV [4650]	1050 Amps (E)	>95%	111.1%	71.4%	allocate power flow via DC controllable injection
P1-2	33203 MISSON 115 33204 POTRERO 115 1 1	115	P1-2:A9:12:_A-P #1 115kV [9932]	788 Amps (E)	76.5%	108%	84.3%	allocate power flow via DC controllable injection
P7-1	33310 SANMATEO 115 33312 BELMONT 115 1 1	115	P7-1:A10:19_Ravenswood-Bair Nos. 1 & 2 115 kV lines	556 Amps (E)	88.2%	105.8%	>95%	allocate power flow via DC controllable injection
P7-1	30689 MARTN S5 230 30695 MARTIN C 230 1 1	230	P7-1:A10:1_Eastshore-San Mateo 230 kV and Pittsburg-San Mateo 230 kV lines	1050 Amps (E)	>95%	105.7%	71.3%	allocate power flow via DC controllable injection
P1-1	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P1-1:A21:5:_TBC_POT2180.50kV & TBC_PTB2180.50kV Gen Units	1050 Amps (E)	>95%	103.2%	74.8%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P1-2:A9:13:_POTRERO-TBC_POT1 #1 115kV [0]	1050 Amps (E)	>95%	102.6%	74.3%	allocate power flow via DC controllable injection
P1-2	30689 MARTN S5 230 30695 MARTIN C 230 1 1	230	P1-2:A16:10:_EASTSHORE-SAN MATEO 230kV [4650]	1050 Amps (E)	>95%	102.6%	72.4%	allocate power flow via DC controllable injection
P7-1	30689 MARTN S5 230 30685 EMBRCDRD 230 2 1	230	P7-1:A10:2_Newark-Ravenswood 230 kV and Tesla-Ravenswood 230 kV lines	1050 Amps (E)	>95%	102.2%	70.1%	allocate power flow via DC controllable injection
P7-1	32950 PITSBURG 115 32970 CLAYTN 115 1 1	115	P7-1:A8:23_Pittsburg-Clayton Nos. 3 & 4 115 kV lines	1762 Amps (E)	98.8%	100%	>95%	allocate power flow via DC controllable injection

If we control the amount of flow injected into the substations we can eliminate the issues identified above and limit the flow to 1231 MW there will be no overload identified.

Table 16 Optimal simultaneous power flow injection

Injection Location	Potrero 230 kV	Los Esteros 230 kV	East Shore 230 kV
Maximum achievable injection (MW)	460.3	380.3	391.7
Limiting element	E. SHORE to SANMATEO 230 kV		
Limiting contingency	P7-1: Newark-Ravenswood 230 kV and Tesla-Ravenswood 230 kV lines		

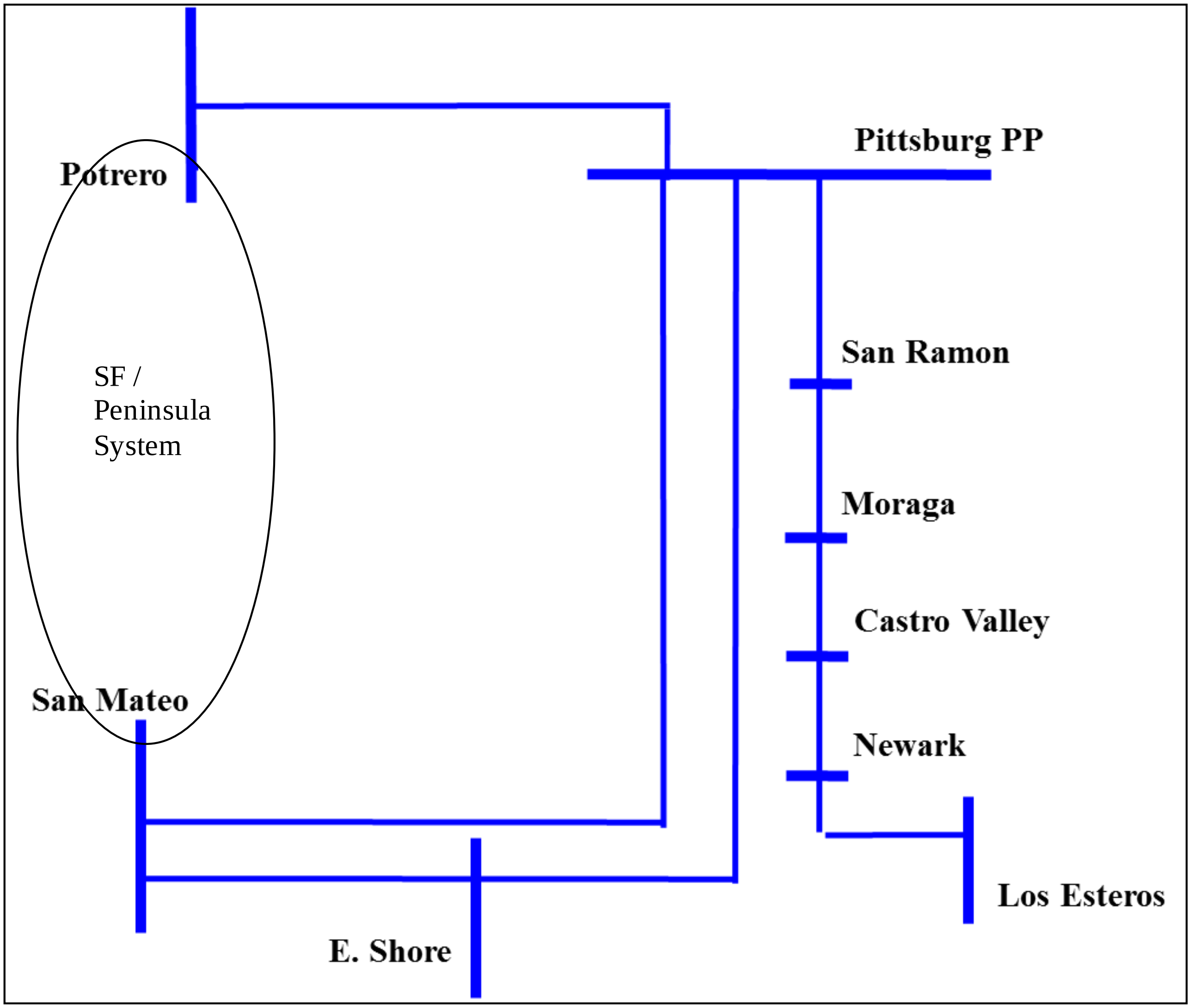


Figure 38 Status Quo Bay Area 230 kV Single Line Diagram

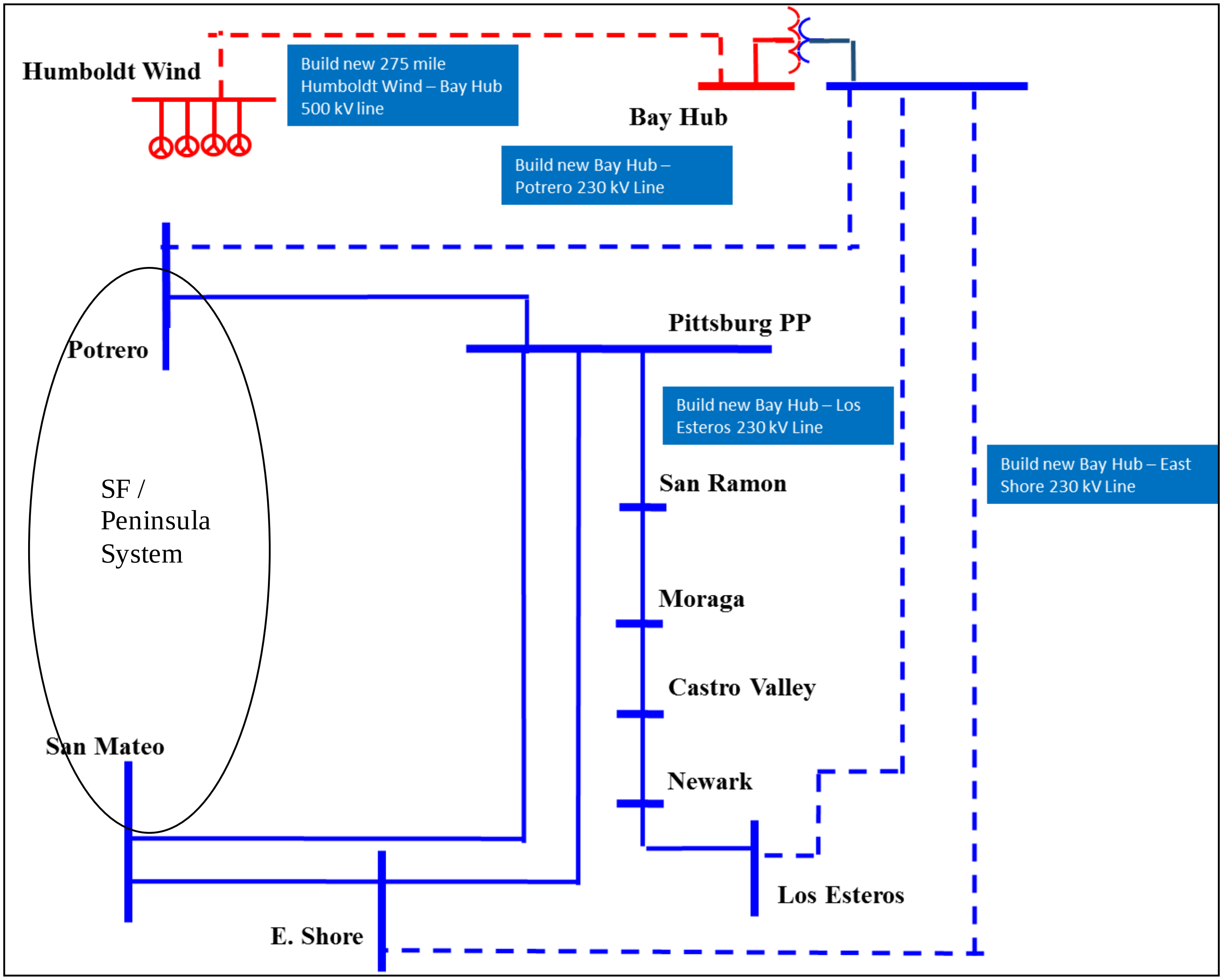


Figure 39 Option 3 Alternative 3 Single Line Diagram

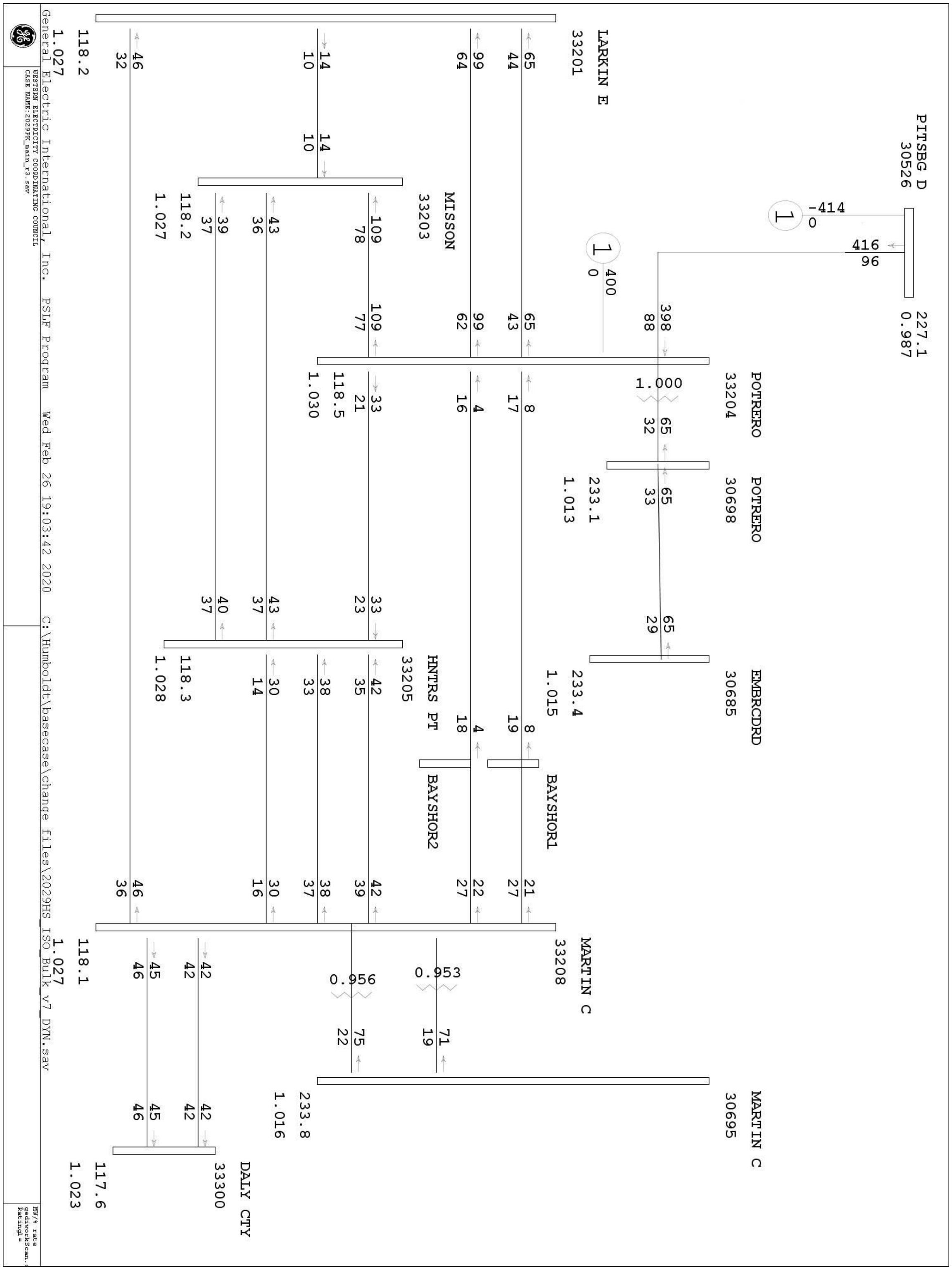


Figure 40 Status Quo 2029 Heavy Summer PSLF Power Flow (N-0)

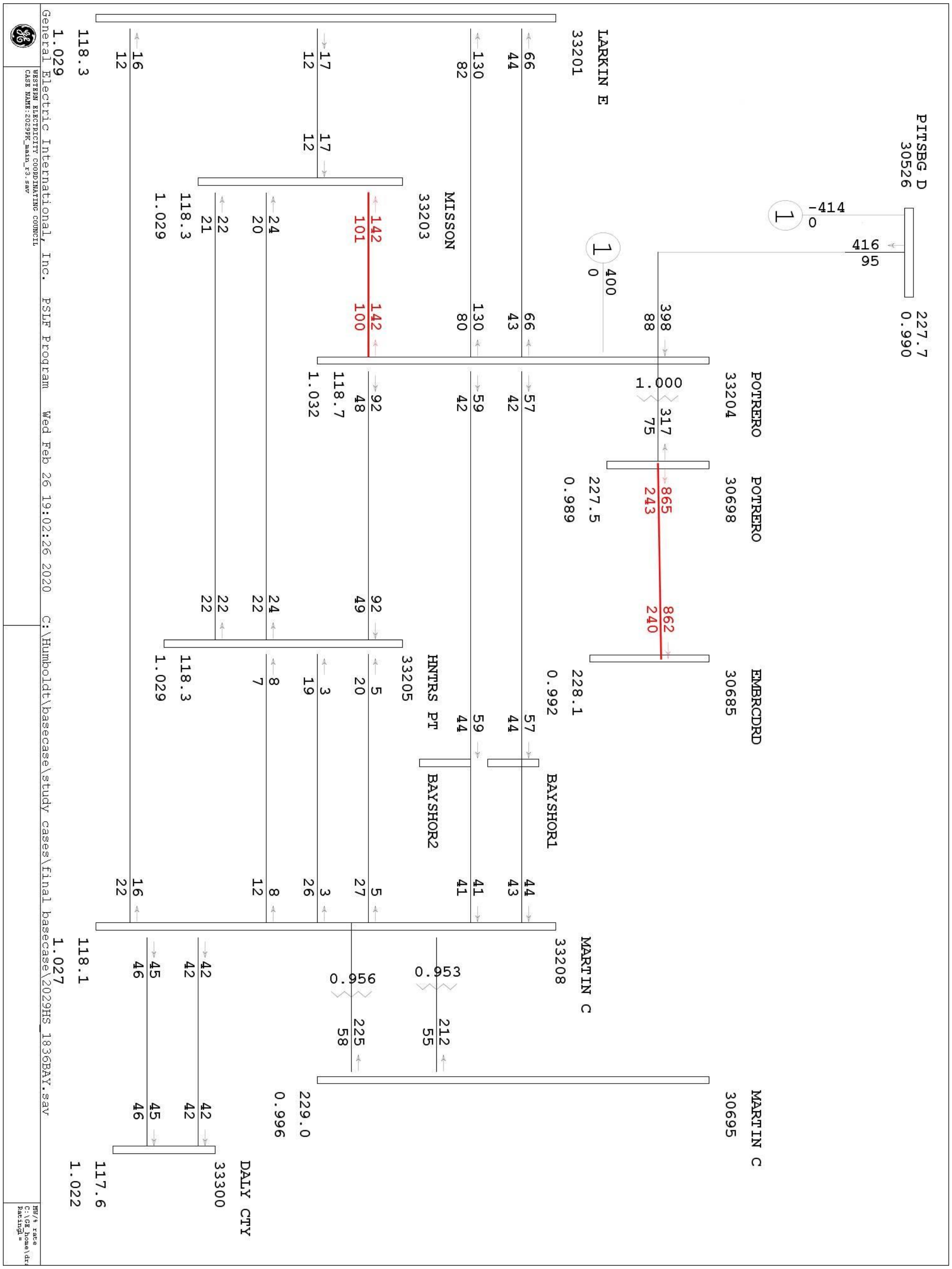


Figure 41 Option 3 Alternative 3 without power flow control on new Bay Hub 230 kV Lines (N-0)

Study Objective and Description of Option 3 Alternatives

The objective of this study is to identify a long-term transmission plan for the interconnection of various generator sizes in the Humboldt area. The 500 kV, 230 kV and 115 kV system were observed to address the capacity and reliability issues that may occur. The alternatives should not alleviate the thermal and voltage violations.

Three alternatives were considered with one being a connection to the east; and the second connects to the southeast. The third alternative is to connect directly to the Bay Area. All alternatives require new substations and substantial new line builds to integrate the new generation interconnection plans requested. The following section provides a general description of the alternatives proposed and associated rough costs. Please note all costs are based on PG&E 2019 unit cost. Costs also do not include any land permitting and right of way costs. Costs also do not include an acquisition of additional land.

Alternative (1): Build new 500 KV Substation and route transmission east

- Build new 120 mile Humboldt Wind - Round Mountain 500 KV Line
- Build new 89 mile Round Mountain - Table Mountain 500 KV Line
- Build new 83 mile Table Mountain - Vaca Dixon 500 kV Line
- Build new 57 mile Vaca Dixon - Tesla 500 kV Line
- Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line

The estimated rough cost for this alternative is about $1.4B-$2.8B.

Alternative (2): Build 500 kV Substation and route transmission southeast

- Build 500 kV Transmission Line from fictitious 500 kV Substation (to be assumed next to Humboldt Bay 115 kV Substation) to Vaca Dixon 500 kV Substation
- Build new Collinsville 500 kV Substation
- Loop Vaca Dixon-Tesla 500 kV line into new station
- Reconductor 25 miles of Vaca Dixon-Collinsville 500 kV Line
- Install 500/230 kV transformer at new station
- Construct two, 5.3-mile subsea 230 kV cables to Pittsburg P.P. Substation
- Install voltage support as required at various locations with the Bay Area

The estimated rough cost for this alternative is about $1.4B-$2.8B.

Alternative (3): Build 500 kV transmission line from Humboldt area to Bay Area

- Build new 275 mile Humboldt Wind - BayHub 500 kV Line
- Build new Bay Hub 500/230 kV Substation
- Build 3-230 kV HVDC subsea cables
  4) Bay Hub - Potrero No. 1 230 kV Line

5) Bay Hub - E. Shore No. 1 230 kV Line
6) Bay Hub - Los Esteros No. 1 230 kV Line

- Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line

The estimated rough cost for this alternative is about $3.5B - $5.8B.

Rough Cost Breakdown

The following table shows a unit cost breakdown for the different alternatives.

Table 17 Cost Breakdown for each Alternative for Option 3

OPTION 3 to interconnect 1836 MW's in Humboldt Area		
Alternative	**Facility**	**Cost Estimate**
Alt: 1 Build 500 kV Line from Humboldt area to Round Mountain 500 kV Substation	Build new 120 mile Humboldt Wind - Round Mountain 500 KV Line	$480M
	Build new 89 mile Round Mountain - Table Mountain 500 KV Line	$360M
	Build new 83 mile Table Mountain - Vaca Dixon 500 kV Line	$336M
	Build new 57 mile Vaca Dixon - Tesla 500 kV Line	$228M
	Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line	$5M
	Total	**$1.4B - $2.8B**
Alt 2: Build 500 kV Line from Humboldt area to Vaca Dixon	Build new 210 mile Humboldt Wind - Vaca Dixon 500 kV Line	$840M
	Build new Collinsville 500 kV Substation	$500M
	Loop Vaca Dixon-Tesla 500 kV line into new Collinsville Substation	
	Reconductor 25 miles of Vaca Dixon-Collinsville 500 kV Line	
	Install 500/230 kV transformer at new station	
	Construct two, 5.3-mile underground 230 kV lines over to Pittsburg P.P. Substation	
	Install voltage support as required at various locations with the Bay Area	
	Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line	$20M
	Reconductor 3 miles of USWP-JRW - Cayetano 230 kV Line	$5M
	Reconductor 3 miles of Cayetano - North Dublin 230 kV Line	$5M
	Reconductor 9 miles of Newark D - NRS 400 115 kV Line	$20M
	Reconductor 8.5 miles of Pittsburg - Clayton 115 kV Line	$13M
	Total	**$1.4B - $2.8B**
Alt 3: Build 500 kV Line from Humboldt area to Bay Area	Build new 275 mile Humboldt Wind - BayHub 500 kV Line	$2.75B*
	Build new Bay Hub 500/230 kV Substation	$800M
	Build 3-230 kV HVDC subsea cables	
	1) Bay Hub - Potrero No. 1 230 kV Line	
	2) Bay Hub - E. Shore No. 1 230 kV Line	
	3) Bay Hub - Los Esteros No. 1 230 kV Line	
	Reconductor 12.5 miles of E. Shore - San Mateo 230 kV Line	$20M
	Total	**$3.5B - $5.8B**

* 50% contingency applied to upper end cost. For all others the AACE Level 5 costs adders were utilized.

Table 18: Cost Breakdown for each Alternative

Conclusion & Recommendation

Option 1

This option considered 48 MW's connected at Humboldt Bay 115 kV Substation. Based on the contingency analysis study results show normal system overloads and overloads caused by single contingencies occur. Analysis performed showed when a loss of a 115 kV transmission line occurred the remainder 115 kV lines overload due to the excess power flow. The current system configuration and capacity would not be able to support 48 MW's connected to the Humboldt system in a heavy summer scenario with Humboldt Generating Station operating at close to or full output. It is recommended to build 115 kV lines to alleviate congestion on the Humboldt 115 kV Transmission grid. Potential upgrades may cost between $365M to $730M.

Option 2

This option considered 144 MW's connected at Humboldt Bay 115 kV Substation. Based on the contingency analysis study results show normal system overloads and overloads caused by single contingencies. Analysis performed showed when a loss of a 115 kV transmission line occurred the remainder 115 kV lines overload due to the excess power flow. The current system configuration and capacity would not be able to support 144 MW's connected to the Humboldt system in a heavy summer scenario with Humboldt Generating Station operating at close to or full output. It is recommended to build 115 kV lines to alleviate congestion on the Humboldt 115 kV Transmission grid. It is also recommended to interconnect to Humboldt 115 kV Substation to offload costs and avoid reconductoring and building a new line to Humboldt Bay 115 kV Substation. Potential upgrades may cost between $669M to $1.34B.

Option 3

Alternative 1

This alternative consists of an interconnection of 1836 MW's from the Humboldt shore to Round Mountain 500 kV Substation. The Round Mountain 500 kV Substation is part of a WECC path 66 connection. In depth studies will need to be performed and coordinated between the CAISO, WECC and Affected Parties. The studies performed indicated with COI fully scheduled there is not enough capacity to interconnect 1836 MW's. It is recommended to build new 500 kV lines from Round Mountain 500 kV Substation down to the major PG&E load center. The load center is served from Vaca Dixon and Tesla 500 kV substations. Contingency analysis was performed for governor power flow and no substantial issues were identified for the additional 500 kV path. It is also recommended that many more robust studies occur to capture voltage and transient stability if it is decided this alternative is viable. Potential upgrades may cost between $1.4B to $2.8B.

Alternative 2

This alternative connects the Humboldt offshore wind to the Vaca Dixon 500 kV Substation. By going directly to the Vaca Dixon substation and a direct path into the bay area with the Collinsville Project, the effects on COI are limited and no substantial issues were identified in governor power flow analysis. The additional scope of work to implement the Collinsville

Project would bring in another 500 kV source into the bay area and serve bay area demand. The Collinsville connection terminates at Pittsburg Substation which has many robust outlets. Transmission lines connect to Potrero (via TBC) and serves the SF area. A connection to San Mateo is also available and serves the Peninsula. The Tri Valley, Fremont and San Jose area also connected to Pittsburg. The Oakland area is also served by Pittsburg. Lastly a major connection to Tesla is also available to import or export any excess power to be distributed throughout PG&E Greater Bay Area transmission system. Potential upgrades may cost between $1.4B to $2.8B.

Alternative 3
This alternative involves building a 500 kV substation within the Bay Area. This 500 kV substation would have three 230 kV lines that export power to Potrero, Los Esteros, and East Shore 230 kV substations. This alternative bypass any connection to the 500 kV Bulk System and all generation is in turn subscribed within the Bay Area. Depending on the allocation of MW's per designated substation the alternatives could include many local upgrades to none at all. In the capacity section of the report more details are provided. It is recommended that the 230 kV lines coming out of the BayHub Substation be DC controllable. Potential upgrades may cost between $3.5B to $5.8B.

The three options evaluated as part of this informational feasibility study, along with the various alternatives to enable exporting the varying levels of offshore wind power generation from the Humboldt coastal region to the electric transmission system backbone, were found to require significant investments in electric transmission infrastructure development. A potential option that could be investigated is the use of storage systems to integrate with the existing infrastructure, particularly during off-peak conditions when generation is not fully utilized giving the grid substantial capacity to transport electricity. For Option 1 and 2, storage systems along with generation management may provide an opportunity to avoid some of the identified local upgrades. However, Option 3 still requires substantial upgrades and new infrastructure to transport such large amount of generation from the coastal region to the middle of the state where the electric system backbone is located and ultimately to the load centers for costumer consumption. It is recommended to revisit these interconnections, particularly the lower level options, with full deliverability not necessarily being the focus but rather studying and understanding when and how much generation could be utilized throughout a period in time. If there are ways to integrate offshore wind generation with the rest of the renewable generation technologies at a reasonable cost, it could benefit grid operators by having more diverse generation to serve customers reliably, especially as California's clean energy goals continue to evolve.