CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
General Equipment						105,688,750
	13090056	HLPD - Meter & Communications Cap - This project captures labor costs incurred to install meters.	3,866,023	-	3,866,023	
	13090630	SAPBM-Capital-Software enhancements associated with the SAP Environment for Business Warehouse (BW) and Finance activities also to address compliance requirements and ensure functional efficiency	1,322,580	-	1,322,580	
	13091508	Customer Information System / Billing Expert System / Transaction Management Hub Mandated Changes - Regulatory required changes tied to market support	1,142,049	-	1,142,049	
	13091909	Oracle Fusion baseline production support (Fusion licenses, product upgrades, server refresh)	2,351,393	-	2,351,393	
	13091924	Dual Data Center Environment-Activities associated with new data center (primariliy hardware purchases and configuration)	1,502,881	-	1,502,881	
	13093827	Replacement of computer hardware, testing equipment and premise equipment including copiers and printers.	1,055,720	-	1,055,720	
	13093863	Purchase of land adjacent to the existing service center for expansion of facilities.	2,792,259	-	2,792,259	
	13094544	Acquisition of new Oracle licenses.	1,743,233	-	1,743,233	
	AA80	Facilities modifications including fencing, shelving, furniture, etc.	40,920,723	-	40,920,723	
	FLEET	Purchase of Vehicles and Power Operated Equipment.	23,532,641	(686,006)	22,846,635	
	HED070	SPLUNK: project includes a software license, infrastructure hardware and implementation services. Splunk is a tool that can consume, retain and search application logs and other raw, unstructured data generated by AMS applications for performance monitoring and application troubleshooting purposes.	2,649,996	-	2,649,996	
	HLP/00/0636	Replacement of the REDE critical infrastructure support systems. These systems include the Mapboard, Video Graphic Recorders and REDE consoles used by RTO System Controllers for power system observibility.	2,715,617	-	2,715,617	
	HXSF	Field Metering - Purchase of in-service metering equipment	6,050,141	-	6,050,141	
	S/101320/CG/WELSH	Capital improvements of the shared Welsh DC tie line facilities	9,767,117	-	9,767,117	
	S/101392/CE/OPSKY	New V&D Radio System: Non production Test System for the OpenSky Voice and Mobile Data Radio System (VMDRS). This allows version upgrades and code changes to be tested before putting into production.	1,460,165	-	1,460,165	
	S/101785/CE/FIBER	Replace aged/degraded fiber on CNP's Core Fiber Backbone	3,502,216	-	3,502,216	
Load Growth						510,353,637

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	AF1A	Planned additions/improvements to the 12kV and 35kV overhead distribution system feeder mains as called for in Planning Issued Distribution Development Plans.	17,988,369	3,716,979	21,705,349	
	AF1H	Overhead services to new customers or adding facilities to accommodate additional load to an existing customer.	36,250,682	2,403,480	38,654,163	
	AF1U	Underground Residential Distribution services to new customers	35,457,339	319,674	35,777,013	
	AF1Z	Only for the installation of overhead service drops and meters to a new customer or service drop replacement to an existing customer adding load where no other facilities are involved.	8,241,424	-	8,241,424	
	AF2A	Unplanned additions/improvements to the 12kV and 35kV overhead distribution system feeder mains relating to area load growth, in conjunction with providing service to customers.	17,298,701	1,634,047	18,932,749	
	AF2H	Overhead line extensions to new Underground Residential Distribution subdivisions.	2,233,969	152,791	2,386,760	
	CE1A	Planned additions/improvements to the 12kV and 35kV distribution system that requires underground feeder mains and underground dips as called for in Planning Issued Distribution Development Plans.	3,661,236	(16,465)	3,644,771	
	CF1R	New major underground services to customers that require three-phase underground facilities to serve their electrical load.	13,724,018	(396,862)	13,327,156	
	DF1U	Streetlight New Installations - Installation of new streetlight standards, and/or luminaires, associated wiring and equipment driven by customer requests for new streetlights.	14,016,708	13	14,016,721	
	HLP/00/0095/0087	Installation of capacitor banks in the Freeport area toprovide reactive power to maintain the system wide voltage	3,106,848	22,305	3,129,153	
	HLP/00/0692	Pearland: Add 7th & 8th 12KV Feeders- Work to add feeders at Pearland substation to support load growth	1,706,239	-	1,706,239	
	HLP/00/0717	Work to provide distribution service for FAA required lighting on structures installed as part of the Brazos Valley Interconnection project.	172,413,595	1,212,302	173,625,897	
	HLP/00/0926	Distribution work to support Freeport area projects.	22,137,837	1,639,879	23,777,716	
	HLP/00/0927/TR/0002	Upgrade transmission ckts 80 and 05 Imperial Taps	2,389,393	-	2,389,393	
	HLP/00/0932	'Interconnection to provide service to generation as required by ERCOT procedure and PUC regulations. Construction and Interconnection of Freeport LNG PTS Generator Oyster Creek.	5,086,435	-	5,086,435	

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	HLP/00/0956	Willow Substation-Add 2-100MVA Transformers/4-35KV Feeders: Substation work to add transformers and feeders to Willow substation to support load growth.	847,543	386,135	1,233,677	
	HLP/00/0966	Fry Road Add 3rdD 100MVA Transformer and 3 Feeders- Work to add transformer and feeders to Fry Road substation to support load growth.	4,963,537	-	4,963,537	
	HLP/00/0986	Deepwater Area Conversions: Project includes: Convert 69kV CHANEL to 138 kV and connect to ckt 70.;Loop ckt 94 L College tap – Witter tap into Deepwater.; Convert 69kV MOCHEM to 138 kV and connect to ckt 70.;Convert 69kV TXPET to 138 kV and connect to ckt 70.	6,691,650	1,008,949	7,700,599	
	HLP/00/0993	Dow Install Second 800 MVA Autotransformer	1,121,453	-	1,121,453	
	HLP/00/0995	Upgrade transmission ckt 81 TH Wharton - Fairbanks. Re-conductor existing 3.63 miles 1-2000AAC ckt 81 from THW to Fairbanks.	3,615,603	669,306	4,284,909	
	HLP/00/0997	Conversion of transmission and substation facilites from 69kv to 138kv from Fort Bend to West Columbia	1,216,534	-	1,216,534	
	HLP/00/1028	Wallis-Add 2nd transformer and 1 Feeder - work to add a transformer and feeder at Wallis substation to support load growth.	3,039,837	-	3,039,837	
	HLP/00/1037	Upgrades of 138 kV transmisson circuit 04 in the Angleton area due to growing industrial customer load.	1,249,133	-	1,249,133	
	HLP/00/1054	Raise 345KV ckts 97 & 99 THWharton-Cedar Bayou to mitigate ground clearance issues.	21,599,093	-	21,599,093	
	HLP/00/1084	New VILLAGE CREEK substation: Purchase of property for new Village Creek distribution substation to support load growth.	13,457,075	-	13,457,075	
	HLP/00/1087	ARCOLA-Add Transformer and Feeders; Work to add transformer and feeders at Arcola substation to support load growth.	5,307,247	-	5,307,247	
	HLP/00/1091	Sienna-Add 3rd Transformer and 2 Feeders- Work to add transformer and feeder at Sienna substation to support load growth.	4,917,915	-	4,917,915	
	HLP/00/1112	Convert HOC substation from 69kv to 138kv	4,918,778	2,728	4,921,506	
	HLP/00/1114	Upgrade transmission ckt 05 Southwyck-Friendswood Tap-Webster	5,676,000	112,481	5,788,482	
	HLP/00/1119	Upgrade transmission ckts 37 and 08 in the Bunker & TECO area	1,451,354	-	1,451,354	
	HLP/00/1122	Build a new Retrieve 138kV substation and tie to TNP near West Columbia to provide a third source for the Phillips Sweeny plant	7,200,466	-	7,200,466	
	HLP/00/1127	Install a new 3rd 800MVA autotransformer at Zenith substation	12,139,806	-	12,139,806	
	HLP/00/1132	Reconductor transmission Ckt 09 from Bellaire to SanFelipe.	2,691,392	61,727	2,753,119	

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	HLP/00/1140	'Interconnection to provide service to generation as required by ERCOT procedure and PUC regulations. Construction and Interconnection for Friendswood Energy	1,147,713	-	1,147,713	
	HLP/00/1144	Rebuild CKT04 Wood H-Frame and 1050' span tower sections from Amoco – Mustang – Algoa Corner using new DT-850 towers	8,538,420	336,989	8,875,409	
	HLP/00/1157	Bringhurst-Replace transformer and add feeder: Work to replace transformer and add feeder at Bringhurst substation to support load growth.	1,297,342	59,840	1,357,182	
	HLP/00/1163	Brazos Valley-Add 3rd Feeder-Work to add feeder at Brazos Valley substation to support load growth.	4,314,553	-	4,314,553	
	HLP/00/1190	Upgrade transmission Ckt 87 from CedarBayou to Aritek as well as supporting substation upgrades.	4,800,686	327,151	5,127,838	
	HLP/00/1196	Hyde Park - Add 3rd Transformer and two Feeders-Work to add transformer and feeders at Hyde Park substation to support load growth.	3,111,185	-	3,111,185	
	HLP/00/1197	Jacintoport - Add 8th Feeder-Work to add feeder at Jacintoport substation rto support load growth.	3,709,379	37,109	3,746,487	
	HLP/00/1219	Reconductor transmisson ckts from Katy to Flewellen.	3,886,992	560,901	4,447,893	
	HLP/00/1223	Glenwood: Upgrade Transformers to 50MVA & add feeder - Work to upgrade transformer capacity and add a feeder at Glenwood substation to support load growth.	3,876,244	-	3,876,244	
	HLP/00/1241	Garth New 35kv Substation-Purchase of property for new Garth distribution substation to support load growth.	3,602,451	-	3,602,451	
Public Improvements						57,026,572
	AD06	The relocation of CEHE overhead distribution facilities that are generally less than five poles, due to customer request, including city, state, and federal government infrastructure improvement projects, such as road widening or roadway improvements.	12,035,519	2,537,354	14,572,873	
	AD07	The relocation of CEHE overhead distribution facilities generally five poles or more, due to customer request, including city, state, and/or federal government infrastructure improvement projects such as road widening or roadway improvements.	13,543,649	3,361,961	16,905,611	
	AD3D	The relocation of CEHE overhead distribution facilities generally five poles or more, due to customer request, including city, state, and/or federal government infrastructure improvement projects such as road widening or roadway improvements.	4,815,019	1,236,468	6,051,488	

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	CG1R	Relocation of major underground facilities for road widening, light rail, etc. Includes relocation of overhead to underground at customer's request.	17,157,602	(425,333)	16,732,268	
	HLP/00/0032/TR/122	Relocation of transmission facilities at US Highway 59 & Interstate 610	2,840,251	(75,919)	2,764,333	
Restoration						49,475,590
	AB48	Reactive capitalized replacements that are made to the underground residential distribution system requiring facility replacement. Includes cable replacement, transformers, and other retirement units and their related components.	3,100,214	-	3,100,214	
	ABCA	Reactive capitalized replacements made to the overhead distribution system requiring facility replacement.	21,386,484	-	21,386,484	
	AD2D	Reactive capitalized replacements made to the overhead distribution system requiring facility replacement resulting from the effects of adverse weather conditions.	3,223,571	640,353	3,863,924	
	AD86	Reactive capitalized replacements made to the overhead distribution system requiring facility replacement resulting from the effects of adverse weather conditions.	5,602,000	1,536,622	7,138,622	
	CD1T	Reactive capitalized replacements made to the major underground system requiring replacement of equipment, cable or structures in response to "lights out." Also includes replacement of system neutral associated with copper theft.	8,093,581	728,566	8,822,147	
	HARVEY	Restoration of system related to damages from Hurrican Harvey; amounts are net of insurance proceeds.	1,860,712	-	1,860,712	
	HLP/00/1222	Replacement of transmission conductor from Stewart to Westbay due to contamination.	962,768	107,551	1,070,320	
	HLP/00/1248	Restoration of transmission lines that cross the San Jacinto River due to damage from Hurricane Harvey.	2,233,166	-	2,233,166	
System Improvements						198,358,937
	AA81	Planned capital replacement or rehabilitation of the overhead distribution system associated with reliability improvement. This includes target top 10% of SAIDI circuits, outage-driven overhead rehab, recurring fuse outages, recurring transformer outages, etc.	1,577,683	-	1,577,683	
	AB1C	Replacement of CEHE-owned poles found defective that are not part of the Groundline Inspection Program or trouble related.	13,353,589	4,173,476	17,527,065	
	AB1G	Planned underground residential distribution cable replacement on a one-span basis. Includes: spans referred from trouble.	2,566,080	762,702	3,328,782	

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	AB1S	Planned underground residential distribution cable replacement of 12kV and 35kV partial and total loops. Includes: cable relocations, transformer relocation/replacements, raising transformers, and pedestals.	5,011,447	1,440,322	6,451,769	
	AB1V	Capacitor banks that include the replacement of capital material such as capacitor, vacuum switches, disconnects, controller, etc.	5,808,963	1,271,258	7,080,220	
	AB1X	Proactive routine capital replacements to the overhead distribution system.	3,385,707	351,927	3,737,635	
	AB1Z	Replacement of CEHE owned poles based on results of the Groundline Inspection Program.	8,042,413	2,252,196	10,294,610	
	AB2G	Install C-truss or other approved brace on CEHE poles identified by the Groundline Inspection Program.	11,732,946	4,712,149	16,445,095	
	AB2S	Cable Life Extension Program - Testing the condition of underground cable and mitigating components of good cable with a high probability of failure.	2,272,852	630,693	2,903,545	
	AFNC	New Capacitor Installations - as part of the Distribution Development Plan to support load growth and demand on the electrical system	1,432,690	2,219	1,434,909	
	CE1B	Proactive replacement of major underground equipment, cable or structures.	10,683,464	536,681	11,220,145	
	DB17	Replacement of streetlight standards and/or luminaires as a result of failure or damage. Does not include area lighting.	4,719,588	345,976	5,065,564	
	DB18	Streetlight LED Replacement- Program replacement of high pressure sodium, metal halide, and mercury vapor streetlight luminaires with LED streetlight luminaires.	16,370,189	(3,105)	16,367,085	
	DB2H	Replacement of streetlight standards due to cable cuts.	7,360,646	2,842,173	10,202,819	
	HLP/00/0011	Unscheduled Substation Corrective Projects- small, unscheduled corrective type projects and unforeseen equipment failures. These projects involve replacement of equipment and or structures.	2,217,080	349,142	2,566,221	
	HLP/00/0012	Scheduled Substation Corrective Projects- small, scheduled corrective projects. These projects involve replacement of equipment and or structures.	1,534,922	421,139	1,956,061	
	HLP/00/0013	Replace failed/obsolete metering equipment at industrial substations or install new metering at new industrila substations	2,479,720	57,417	2,537,137	
	HLP/00/0014	Replace the logic cages in aging and/or unreliable SCADA Remote Terminal Units (RTU's).	1,648,660	142,398	1,791,058	

CenterPoint Energy Houston Electric
Capital Project List
Calendar 2018

Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	HLP/00/0054/TR/0001-C	Replace deteriorating transmission facilities that if left in place could lead to outages in the near future and less reliable service.	10,615,000	2,134,425	12,749,425	
	HLP/00/0075	This project provides funding for replacement of failed distribution and transmission transformers as well as replacement of failed transmission circuit breakers. (Transformers may be rewound and the rewind would be capitalized)	29,544,709	17,769	29,562,477	
	HLP/00/0187	Replace obsolete and unreliable circuit switchers.	1,860,254	369,084	2,229,339	
	HLP/00/0484	Substation Security Upgrades - Installation of security equipment to control physical and cyber access to CNP substations. This includes: Plant separation fencing, security cameras, & cyber security equipment at various substations. These substations are selected based on risk, vulnerability, and impact as determined by CNP security policies and/or future regulatory requirements.	1,676,457	469,632	2,146,089	
	HLP/00/0582	Install Switch onto Fault (SOTF) relay protection on the 138KV grid.	1,658,839	430,726	2,089,565	
	HLP/00/0667	This project is to provide funding for replacement of older 345kV Westinghouse, LWE live-tank breakers with newer SF6 gas puffer design single-break units.	917,159	241,606	1,158,765	
	HLP/00/0668	This project is to provide funding for the replacement of 138 KV and 69KV old oil breakers with newer technology SF6 gas breakers.	2,680,370	542,742	3,223,113	
	HLP/00/0672	This program provides for various protection improvements on the substation system. Work covered with these amounts was associated with the installation of a 35kv breaker at Satsuma Substation.	1,366,952	72,478	1,439,429	
	HLP/00/0798	Add dual pilot 138kv line relaying for improved protection and reliability.	1,201,230	39,111	1,240,341	
	HLP/00/0922/TR/0004	Hardening of transmission facilities from Gable Street - Franklin - Crocket - Downtown	2,569,948	420,719	2,990,667	
	HLP/00/1055	Distribution line clearance corrections between transmission and distribution facilities to meet National Electrical Safety Code (NESC) requirements.	1,520,607	209,792	1,730,399	
	HLP/00/1099	Substation Physical Security Enhancement: Replacement of substation facility fencing with more protective fencing to ensure our critical assets receive a greater level of protection.	175,425	1,851,076	2,026,501	

CenterPoint Energy Houston Electric
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Project Category	Project Number	Description	Additions	Net Salvage	Total	Project Category Total
	HLP/00/1247	Rebuild Memorial substation due to extensive damage due to Hurricane Harvey. Rebuild included upgrade of transformers and storm hardening measures to mitigte future flooding iisues.	13,285,426	-	13,285,426	
Intelligent Grid						18,131,097
	Post AMS	Project for the deployment of approximately 2.4 million advanced meters and the associated telecommunications and information systems to support the functions of the meters. Also includes additional systems and enhancements to our existing systems to support the AMS meters such as hardware to support storage of AMS information; enhancements to the interface platform that allows AMS systems to communicate with other CenterPoint Electric systems; enhancements to the customer information system to support AMS; enhancements to support analytics utilizing AMS data; and enhancements to SmartMeter Texas to support new market requirements. These costs were not included in the AMS surcharge.	6,068,462	(225,191)	5,843,271	
	IG	Intelligent Grid Project provides enhanced monitoring, interrogation, and control capability of the distribution grid. The project consists of installation and integration of the Advanced Distribution Management System (ADMS) and installation of field infrastructure.	11,638,006	649,820	12,287,826	
		Total of Projects Greater than $1,000,000	888,308,952	50,725,631	939,034,583	939,034,583
		Total of Projects Less than $1,000,000	43,544,778	6,770,872	50,315,650	50,315,650
		Total of All Projects	931,853,730	57,496,503	989,350,233	989,350,233

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TO

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APPLICATION OF CENTERPOINT	**§**	**PUBLIC UTILITY COMMISSION**
ENERGY HOUSTON ELECTRIC, LLC	**§**	
FOR AUTHORITY TO CHANGE RATES	**§**	**OF TEXAS**

DIRECT TESTIMONY

OF

MARTIN W. NARENDORF JR.

ON BEHALF OF

CENTERPOINT ENERGY HOUSTON ELECTRIC, LLC

April 2019

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GLOSSARY OF ACRONYMS AND DEFINED TERMS

1. CCN – Certificate of Convenience and Necessity
2. CREZ – Competitive Renewable Energy Zone
3. CSC – Commercially Significant Constraint
4. ERCOT – Electric Reliability Council of Texas
5. FERC – Federal Energy Regulatory Commission
6. FIS – Full Interconnection Study
7. ISO – Independent System Operator
8. kV – Kilovolts
9. MVAR – Megavolt Ampere Reactive
10. NERC – North American Electric Reliability Corporation
11. O&M – Operations and Maintenance
12. OSHA – Occupational Safety and Health Administration
13. RTO – Real Time Operations
14. RMR – Reliability Must Run
15. STP – South Texas Project
16. SCADA – Supervisory Control and Data Acquisition
17. TCOS – Transmission Cost of Service
18. Texas RE – Texas Regional Entity
19. TMPA – Texas Municipal Power Agency
20. TNMP – Texas New Mexico Power Company
21. TSP – Transmission Service Provider

EXECUTIVE SUMMARY OF MARTIN W. NARENDORF JR.

CenterPoint Energy Houston Electric, LLC's ("CenterPoint Houston" or the "Company") High Voltage Operations Division constructs, operates, and maintains the Company's transmission, substation, and three-phase underground distribution ("Major Underground") facilities. My testimony supports the Company's capital investment and Operations and Maintenance ("O&M") expense as they relate to transmission, substation, and Major Underground assets and day-to-day operations. Specifically, my testimony:

- explains the structure and functions of the High Voltage Operations division; and
- supports the reasonableness and necessity of High Voltage Operations-related O&M expense incurred during the 2018 test year in the amount of approximately $58.8 million; and
- supports the reasonableness and necessity of approximately $3.0 billion in transmission, substation, and Major Underground capital investment placed in service from January 2010 through December 2018.

Together with the cost of service data and testimony of the Company's other witnesses, my testimony and supporting materials demonstrate that the capital expenditures for the transmission, substation, and Major Underground assets and test year O&M expense for High Voltage Operations are reasonable, necessary, and representative of the costs to provide service to customers of CenterPoint Houston and thus, should be included in the Company's cost of service.

DIRECT TESTIMONY OF MARTIN NARENDORF JR.

I. <u>INTRODUCTION</u>

Q. PLEASE STATE YOUR NAME AND OCCUPATION.

A. My name is Martin W. Narendorf Jr. I am employed by CenterPoint Energy Houston Electric, LLC ("CenterPoint Houston" or "the Company") as Vice President of High Voltage Operations.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A. I received a Bachelor of Science Degree in Electrical Engineering from the University of Houston in 1982. I have been employed by CenterPoint Energy, Inc. ("CNP") or one of its affiliates since 1983. My positions with CNP have included engineer and senior engineer in Electrical System protection, Engineering Projects, Supervising Engineer in Zone Technical engineering and Meter Shop Operations, Regional Operations Manager of North and Northwest Regions at Electropaulo, the utility serving one-fourth of the population of Sao Paulo Brazil, Director of Operations at Spring Branch Service center, Senior Director of Substation Operations and Asset Management and Vice President of Power Delivery Solutions. I was named to my present position in 2018, at which time I assumed responsibility for the High Voltage Operations division of CenterPoint Houston.

Q. WHAT ARE YOUR CURRENT RESPONSIBILITIES?

A. As Vice President of High Voltage Operations, my responsibilities include the installation, operations and maintenance ("O&M") of the transmission, substation and Major Underground facilities and the command and control function of the Company's transmission system through Real Time Operations ("RTO").

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS PROCEEDING?

A. I am testifying on behalf of CenterPoint Houston.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. My testimony provides an overview of CenterPoint Houston's High Voltage Operations division. I also support the overall reasonableness and necessity of the O&M expense level for CenterPoint Houston High Voltage Operations in the 2018 test year and the prudence of capital investment in transmission, substation, and Major Underground assets from January 1, 2010 through December 31, 2018.

Q. PLEASE DESCRIBE THE INTERACTION OF YOUR TESTIMONY WITH OTHER WITNESSES IN THIS CASE.

A. My testimony sponsors the Company's transmission, substation, and Major Underground capital investment and O&M expense for the High Voltage Operations Division. Company witness Dale Bodden's testimony describes the engineering, planning, design and capital budgeting process for both the distribution and transmission system and supports the reasonableness and necessity of the test year O&M expense associated with the Engineering and Asset Management division. Company witness Julienne P. Sugarek's testimony supports the reasonableness and necessity of the test year O&M expense associated with the Power Delivery Solutions division. Company witness Randal M. Pryor's testimony describes the distribution delivery system and demonstrates that capital and test year O&M expense associated with the Company's distribution facilities are reasonable and necessary. Company witness Michelle M. Townsend discusses allocated costs associated with the regulated support organizations and the Service Company, LLP. Company witness Kristie L. Colvin provides testimony on the Company's overall planning and budgeting process and cost of service adjustments.

II. TRANSMISSION DELIVERY SYSTEM

Q. WHAT ASSETS MAKE UP THE COMPANY'S TRANSMISSION DELIVERY SYSTEM?

A. The electric transmission delivery system is the portion of the Company's electric system that operates at high voltage - voltages of 60 kilovolt ("kV") or higher. The transmission delivery system consists of transmission lines, including the associated towers, poles, conductors, insulators and other components; the Company's transmission control center; and various equipment at electrical substations, including the associated circuit breakers, transformers, capacitors, switches, Supervisory Control and Data Acquisition ("SCADA") equipment, and relay control equipment.

As of December 31, 2018, CenterPoint Houston owned 3,834 circuit miles of overhead and underground transmission lines, including 268 circuit miles operated at 69 kV; 2,231 circuit miles operated at 138 kV; and 1,336 circuit miles operated at 345 kV. Power is transmitted via the transmission system to 234 substations owned by CenterPoint Houston and 163 substations owned by third parties, where large end-use customers are provided electric service at transmission voltage levels, as well as other transmission systems within the Electric Reliability Council of Texas ("ERCOT") Region. At distribution substations, the voltage level of the power is reduced through transformers to CenterPoint Houston's standard primary distribution voltages of 12 kV and 35 kV.

Q. WHERE DOES THE TRANSMISSION SYSTEM END AND THE DISTRIBUTION SYSTEM BEGIN?

A. The transmission system ends, and the distribution system begins, at the high side bushings of the transmission-to-distribution voltage transformers. The transmission-to-distribution voltage transformers are considered distribution equipment but are maintained by my organization. The functions of the distribution system are explained in Mr. Pryor's testimony.

Q. HOW ARE THE FACILITIES WITHIN SUBSTATIONS ALLOCATED BETWEEN TRANSMISSION COSTS AND DISTRIBUTION COSTS?

A. 16 Texas Administrative Code ("TAC") § 25.192(c)(1) defines facilities that are deemed to be transmission assets. The Company determines the allocation of assets between transmission and distribution plant in-service based on that rule. As such, the power transformers that transfer energy from transmission voltage facilities (69 kV and above) to distribution voltage facilities (35 kV and below) are allocated to distribution plant in-service. Except for certain distribution voltage capacitor banks as described in 16 TAC § 25.192, electrical facilities in the substation operated at distribution voltage are allocated to distribution plant in-service and electrical facilities in the substation operated at transmission voltage are allocated to transmission plant in-service. Facilities that support the underlying transmission or distribution electrical facilities, such as foundations, control cable, conduit, and relay panels, are allocated based on the electrical facility they support.

III. DESCRIPTION OF HIGH VOLTAGE OPERATIONS ORGANIZATION

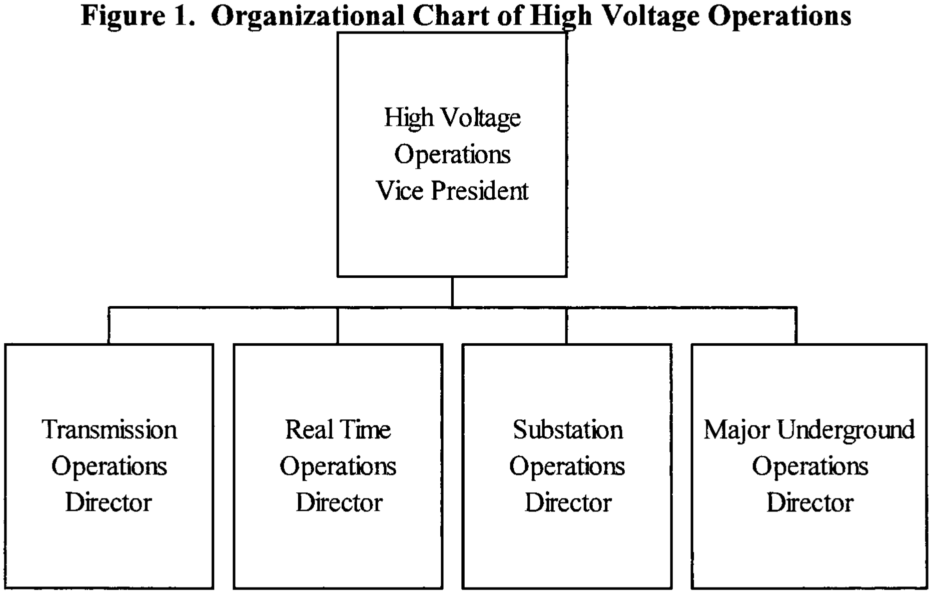
Q. PLEASE DESCRIBE THE HIGH VOLTAGE OPERATIONS DIVISION'S PRIMARY FUNCTION AND OBJECTIVES.

A. The departments within High Voltage Operations during the 2018 test year are responsible for construction, operation, and maintenance of the Company's transmission, substation, and Major Underground facilities and the command and control function of the Company's Transmission system through RTO. These departments work together to provide non-discriminatory, reliable, and safe electric service that enable efficient energy transfers in compliance with all applicable laws and regulations.

Q. WHAT IS THE BASIC STRUCTURE OF THE HIGH VOLTAGE OPERATIONS DIVISION?

A. In 2018, High Voltage Operations was divided into four departments: Transmission Operations, RTO, Substation Operations, and Major Underground Operations, as shown in Figure 1.

Figure 1. Organizational Chart of High Voltage Operations



Q. PLEASE DESCRIBE THE MAIN FUNCTIONS OF THE TRANSMISSION OPERATIONS DEPARTMENT.

A. Transmission Operations is responsible for the construction and O&M of the Company's transmission facilities. Transmission operations has internal employees performing regular maintenance, operations, and construction on the Company's transmission assets. For large transmission line maintenance or construction projects using contractor resources, Transmission Operations determines the scope of work to be performed, manages the bid selection process, ensures quality control of project construction and ensures payment for services rendered. Transmission Operations works closely with engineering groups to schedule projects, develop cost estimates, and track progress against these controls throughout the project. Additionally, Transmission Operations coordinates with RTO to schedule work during ERCOT-approved outage times, when necessary.

Q. WHAT ARE THE MAIN FUNCTIONS OF THE RTO DEPARTMENT?

A. RTO maintains and operates the Company's local control center, which supports operations of the ERCOT Region under the oversight of the ERCOT Independent System Operator ("ISO"). In cooperation with and under the direction of the ERCOT ISO, RTO monitors transmission network conditions and performs control actions to ensure reliability in compliance with ERCOT Operating Guides and North American Electric Reliability Corporation ("NERC") reliability standards. Of necessity, the bulk of the System Controllers work on shift schedules as this organization must perform its functions 24 hours a day, every day, including weekends and holidays. CenterPoint Houston System Controllers are certified under the NERC System Operator Certification Program. RTO coordinates with internal Company departments and various external organizations, such as large industrial customers or generators, on scheduling outages, subject to ERCOT review and approval, to support construction and maintenance activities. Engineers and technical support personnel support RTO by evaluating reliability impacts and coordinating scheduled transmission element outages, initiating updates to CenterPoint Houston and ERCOT transmission system operational models, evaluating and assisting with operating concerns, and assisting with training and reliability compliance documentation.

Q. WHAT ARE THE RESPONSIBILITIES OF THE SUBSTATION OPERATIONS DEPARTMENT?

A. Substation Operations is responsible for the construction, maintenance, and operation of the Company's substation facilities. The Substation Operations department is primarily composed of specialized electricians, who are assigned to the Diagnostic section, the Oil Servicing section, the Network & SCADA section, or one of three Maintenance sections. The Diagnostic section conducts diagnostic tests on equipment to detect reliability problems before they occur. The Oil Servicing section is responsible for the replacement and installation of substation transformers and all major transformer maintenance and repairs. The Network and SCADA section is responsible for the installation, programming, and security of substation communication network and SCADA systems. The three Maintenance sections are responsible for operating and maintaining the power equipment and associated controls and peripherals of CenterPoint Houston's substations. This includes switching equipment and lines in order to perform maintenance; repairs and expansion of substations; substation security; vegetation management; station checks; and load readings and analysis of substation parameters. The Maintenance sections perform maintenance on substation equipment to ensure that all equipment is calibrated and serviced to meet manufacturer specifications. Additionally, maintenance employees commission new and replacement equipment by providing assistance with installation and acceptance testing of equipment, as well as calibration and functional testing of equipment. Substation Operations also has Network specialists, Policy and Compliance coordinators, and Technical Analysts to support the organization.

Q. PLEASE DESCRIBE THE MAIN FUNCTIONS OF THE MAJOR UNDERGROUND OPERATIONS DEPARTMENT.

A. Major Underground Operations is responsible for the construction, maintenance, and operation of the Company's three-phase underground facilities. This includes designated underground areas, such as downtown Houston, the Texas Medical Center, and George Bush Intercontinental Airport, as well as individual commercial loads served with three-phase padmount transformers, underground getaways from substations, and underground dips under freeways. Major Underground Operations consists of bargaining unit employees and management/administrative staff. The bargaining unit is composed of specialized cable splicers, underground network testers, and heavy equipment operators, who are assigned to either the Relay group or one of the two Cable groups. The Cable groups install equipment and cable, along with the necessary splices and terminations to interconnect the underground system, including fiber optic cable systems. The Relay group installs, programs, and maintains protective relaying systems, SCADA systems, and underground communication network systems. The Relay group also programs and maintains power equipment control devices such as breakers, automatic switches, and network protectors. Both the Cable and Relay group execute clearance switching as needed to safely perform maintenance and repairs of power system equipment and control devices. All civil construction such as concrete-encased ductbank, equipment pads, and underground boring is performed through the use of contractors.

Q. HOW DO THESE FOUR DEPARTMENTS OPERATE TOGETHER ON A DAY-TO-DAY BASIS?

A. Transmission Operations, Substation Operations, RTO, and Major Underground work together to build and operate the largest scale assets within CenterPoint Houston's delivery system. High Voltage Operations is responsible for delivering power from all over ERCOT to high voltage industrial customers, large underground vaults serving commercial customers, and CenterPoint Houston-owned substations where Distribution Operations then delivers the power to customers connected to the distribution system. These four entities coordinate and collaborate daily to provide safe, robust, reliable and resilient electric grid operations and electric service to our customers.

IV. HIGH VOLTAGE OPERATIONS O&M EXPENDITURES

Q. WHAT ARE THE TOTAL O&M EXPENDITURES ATTRIBUTABLE TO THE HIGH VOLTAGE OPERATIONS ORGANIZATION FOR THE TEST YEAR?

A. Test year O&M expenditures for High Voltage Operations totaled approximately $58.7 million. Figure 2 shows the test-year expense for each department.

Figure 2. Test-Year O&M Expense by Department for High Voltage Operations

High Voltage Operations O&M by Department	Total Test Year Expense
Real Time Operations	$6,489,762
Transmission Operations	$10,543,016
Major Underground Operations	$8,036,449
Substation Operations	$32,084,634
Administration & General	$1,614,479
Total	**$58,768,339**

Q. WHAT ACTIVITIES ARE INCLUDED IN THE TEST YEAR AS O&M EXPENSES?

A. O&M expenditures are related to activities such as transmission, substation, and three-phase underground facility inspections and the ongoing maintenance of those facilities; 24-hour control and dispatch of the transmission system, including operation and maintenance of the transmission control center; service restoration; emergency preparedness; research and development and technology upgrades; and expenses required for meetings, training, and organization dues.

Q. HOW DOES CENTERPOINT HOUSTON ENSURE THAT ITS TRANSMISSION AND SUBSTATION MAINTENANCE PRACTICES ARE REASONABLE AND PRUDENT?

A. CenterPoint Houston has well-established, reasonable O&M practices for its transmission, substation, and Major Underground facilities. For instance, CenterPoint Houston employs a five-year physical inspection cycle for its transmission facilities, and a one-year aerial inspection cycle. CenterPoint Houston follows NERC standard PRC-005-6 for Bulk Electric System ("BES") protection equipment testing and maintenance, which specifies types of equipment requiring testing and the designated testing intervals. Work orders for equipment designated in PRC-005-6 are automatically generated and available to Substation Operations in advance to allow enough time to complete the work well before deadlines. All High Voltage Operations maintenance plans are made up of maintenance strategies, which set frequencies, and task lists that set the job scope and hourly standards. The Company compares maintenance practices with other utilities at peer conferences and working groups. Maintenance interval recommendations from equipment manufacturers and our own failure analysis data is also used to establish best practices and metrics for maintenance. All High Voltage Operations departments perform budget analysis monthly to monitor O&M spend.

Q. HAS THE COMPANY INSTITUTED ANY CHANGES IN ITS DAY-TO-DAY OPERATIONAL PRACTICES SINCE ITS LAST RATE PROCEEDING IN ORDER TO IMPROVE EFFICIENCY, SAFETY AND OR RELIABILITY?

A. Yes. The Company has introduced a number of innovative changes aimed at improving efficiency, safety, and reliability since its last rate case:

- Major Underground now uses a remote-operated robotic jackhammer machine to chip into concrete-encased duct banks instead of workers with handheld jackhammers chipping directly on the energized concrete-encased duct banks. This removed the worker from an environment requiring Personal Protective Equipment to mitigate exposure to energized conductor work as well as exposure to silica dust.

- Major Underground switched to standard off-the-shelf mechanical cable splices instead of custom hand-taped cable splices, eliminating the need for molten metal, fumes, and improving worker ergonomics. This also resulted in improved reliability through standardization, as well as less time required per splice.

- Major Underground now uses a "non-entry" manhole rescue system that allows workers to be quickly extracted from a manhole in an emergency situation, without sending a second worker into the manhole. This is critically important if the manhole has filled with smoke or a harmful agent.

- Substation now uses ground-based LIDAR to build 3D models of existing substations before making modifications. This 3D LIDAR mapping is performed during the design phase of a project and provides the ability to identify potential equipment clearance issues earlier in the design process.

- Substation and Transmission now use a Traveling Wave System ("TWS") on high voltage transmission circuits to provide faster and improved fault location accuracy to within one span to aid transmission line patrols in finding the root cause of line faults and to begin restoration of circuits faster. Through the end of 2018, TWS is installed on 97% of 345 kV, 68% of 138 kV, and 3% of 69 kV circuits.

- One challenge that CenterPoint Houston faces is the ability to get the necessary transmission line outages needed to perform routine maintenance or to connect new facilities. ERCOT limits line outages during peak summer months (June through September) and since the peak season has recently started to extend into May and October, the Company becomes increasingly pressed to condense all the necessary work into a shorter timeframe. In an effort to maximize productivity during non-peak months, the Company invested in heavy duty tracked equipment which allows construction crews access to areas despite muddy or wet conditions, decreasing idle time and increasing productivity. Additionally, the Company expanded its fleet of versatile, reusable, light duty, steel poles and associated hardware to construct temporary bypasses when long-term circuit outages are restricted.

- Transmission Operations has also taken an active role in research and development efforts, specifically the Occupational Safety and Health Administration Transient Over Voltage task force, focused on live line work practices. Through involvement in this program, the Company was able to decrease the minimum approach distance which enables field personnel to perform more work on energized lines.

- Transmission Operations has also been involved in development of new line tools in cooperation with the Electric Power Research Institute which includes: 1) a self-contained, automated, conductor cleaner for efficiently deep cleaning of conductors for splicing and terminations with improved, long-term electrical performance; 2) a non-ceramic insulator tester for hot line workers to test the electrical integrity of new insulators before installing them during live work; and 3) insulator contamination sensors and improved non-ceramic insulator contamination designs to reduce the need for insulator washing and for better electrical performance in coastal salt contamination zones.

- RTO has made several digital improvements to increase efficiency, including electronic switching documentation, digital basic one line editing and storage, digital shift relief, and switching documentation and action numerical tracking. These digital records allow for better access to and quicker recovery of vital information during a catastrophic event while also providing the opportunity to analyze historical information for additional improvements.

- RTO now uses a load forecasting solution that allows for more efficient forecasting of Houston-based load which includes a learning algorithm to improve forecast accuracy over time.

Q. ARE THE HISTORICAL TEST YEAR O&M EXPENSE OF THE HIGH VOLTAGE OPERATIONS ORGANIZATION DISCUSSED IN THIS PROCEEDING REASONABLE AND NECESSARY?

A. Yes. The test year O&M expense for High Voltage Operations were related to necessary functions that directly impacted the reliability and operation of the transmission system to serve both existing and new customers.

V. HIGH VOLTAGE CAPITAL INVESTMENTS

Q. PLEASE DESCRIBE THE CAPITAL INVESTMENT FOR WHICH THE COMPANY SEEKS A PRUDENCE DETERMINATION IN THIS CASE.

A. CenterPoint Houston must continually invest in its transmission, substation, and Major Underground infrastructure to ensure the safe and reliable provision of electric service. To this end, between January 1, 2010 and December 31, 2018, CenterPoint Houston's high voltage capital investments total approximately $3.0 billion. My testimony discusses the reasonableness and necessity of these capital investments in five broad categories: (1) interconnections, (2) load growth, (3) system improvements, (4) restoration, and (5) operations support investment. These costs are identified in Figure 3, Capital Investment by Category.

Figure 3. Capital Investment by Category for High Voltage Operations

High Voltage Operations Capital Investment by Category	Investment in millions
Interconnections	460.9
Load Growth	1,506.7
System Improvements	754.5
Restoration	93.8
Operations and Support	220.5
Total	**$ 3,036.4**

A. **System Interconnections**

Q. WHAT SYSTEM INTERCONNECTION INVESTMENT IS INCLUDED IN THIS PROCEEDING?

A. In this proceeding, "System Interconnections" generally refers to projects constructed to directly interconnect new generators to the transmission system, transmission and substation facilities built in order to import or export power to or from areas outside of CenterPoint Houston's system, and substation capacitor bank additions. Under Public Utility Commission of Texas ("Commission") rules, transmission and substation costs necessary to interconnect new generating units are generally not collected from generators but are recovered through rates.

Q. HOW MANY INTERCONNECTIONS TO NEW GENERATING SITES HAVE OCCURRED ON CENTERPOINT HOUSTON'S TRANSMISSION SYSTEM SINCE 2009?

A. Since 2009, CenterPoint Houston interconnected eight new generating plant sites: PHR Peaking Units, NASA Cogen Facility, Freeport LNG, Net Power, Friendswood Energy, Castleman Chamon, Colorado Bend Energy II and Bailey and Ineos Hudson.

Q. PLEASE DESCRIBE THESE PLANT INTERCONNECTIONS.

A. Six out of these eight generation interconnections occurred at existing substations or behind customer-owned substations, so minimal interconnection facilities were needed. The two generation interconnections requiring new facilities were Freeport LNG generators and Colorado Bend Energy II. Freeport LNG installed 82 MW of natural gas generation at their pre-treatment facilities. To connect this generation to the 138 kV system, CenterPoint Houston constructed Oyster Creek interconnecting switchyard, which Freeport LNG securitized for $18.8 million. Colorado Bend Energy II is a 1,125 MW gas turbine generator, owned by Exelon, that is connected to CenterPoint Houston's 345 kV system in Wharton County. The Company constructed a 345 kV switchyard, Bailey substation, as the point of interconnection between Exelon's generation facilities and CenterPoint Houston's transmission facilities. Exelon securitized $16.2 million for the construction of Bailey Substation and that securitization was released after the generating units achieved full commercial operation in 2017.

Q. WHAT ARE SOME OF THE FACTORS THAT AFFECT GENERATOR INTERCONNECTION COSTS?

A. The main driver of generation plant interconnection cost is proximity of the generating unit to electrical facilities of adequate size to accommodate the interconnection. If a generation plant is built close to an existing, expandable substation, CenterPoint Houston can extend a generator lead to the plant with minimal construction costs. If the plant requires a new interconnecting switchyard, the cost will be higher. Proximity to the transmission facilities also drive cost based on the length of the service extension necessary. CenterPoint Houston's Transmission Planning department studies each generation interconnection in coordination with and under supervision of ERCOT to determine possible interconnection options and the impact of those interconnections to the transmission system. When multiple interconnection options exist, the most reasonable and cost-effective interconnection option, considering direct connection costs and reasonably anticipated upgrades, is selected.

Q. **WHAT MAJOR IMPORT OR EXPORT PROJECTS DID CENTERPOINT HOUSTON COMPLETE BETWEEN 2010 and 2018?**

A. The largest transmission interconnection project completed during the 2010 through 2018 time frame was the Brazos Valley Connection ("BVC"), a 60-mile, 345 kV double circuit line extending from Zenith substation to Gibbons Creek substation which was energized in March 2018.

Q. **WHAT NEEDS DID THE BVC PROJECT ADDRESS?**

A. The BVC project was part of a larger project, the Houston Import Project ("HIP"), which included the installation of a 345 kV double circuit transmission line from Zenith substation to Limestone substation. CenterPoint Houston's Transmission Planning department studied the import needs for the Houston area and identified a need for additional import capacity starting in 2018. CenterPoint Houston then identified 25 alternatives to address these needs and ensure reliable power for the Houston region and submitted the study to ERCOT in July 2013. ERCOT Staff, Regional Planning Group, Technical Advisory Committee, and Board of Directors reviewed the study and ultimately recommended the construction of the HIP in April 2014. CenterPoint Houston was identified as the utility to develop and construct the southern portion of the HIP between Harris and Grimes Counties while Cross Texas Transmission and the City of Garland constructed the northern portion. Once notified of this decision, CenterPoint Houston named its segment the Brazos Valley Connection.

Q. WERE THE COMPANY'S EFFORTS RELATED TO THE BVC PROJECT SUCCESSFUL?

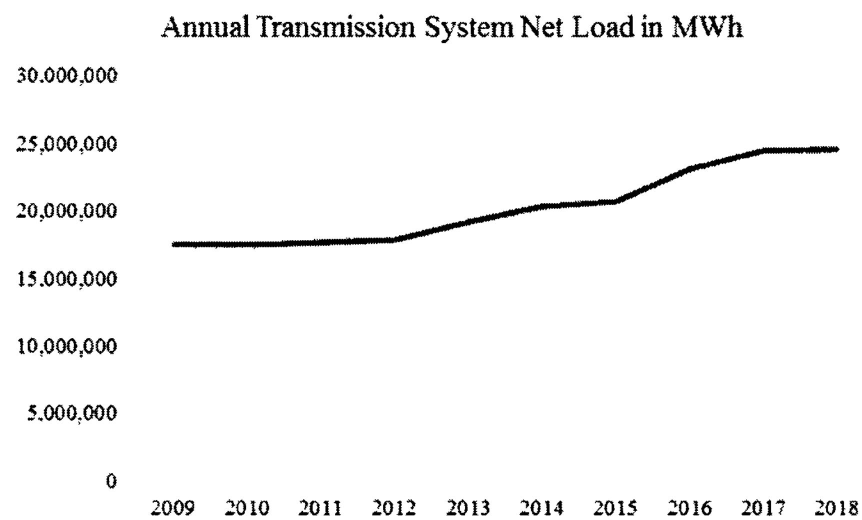
A. Yes. After a thorough routing study was performed, the Company filed an application to amend a Certificate of Convenience and Necessity for the proposed BVC under Docket No. 44547. CenterPoint Houston received approval to build the BVC on January 15, 2016. Following the Commission's approval, the Commission later modified its final order to require the use of monopoles rather than tower structures everywhere along the route except inside substations. CenterPoint Houston immediately began engineering design and right-of-way acquisition activities. The estimated budget for the BVC project, along the approved route, with use of monopoles, was $296.3 million. The final project cost was $276.2 million. The target completion date for the HIP was June 2018. CenterPoint Houston completed the BVC portion of the project on March 8, 2018 and energized the line on March 29, 2018. Cross Texas Transmission and City of Garland energized the northern portion of the line in mid-April 2018 completing the project and placing it in service ahead of schedule.

B. Load Growth

Q. PLEASE DESCRIBE THE LOAD GROWTH THE COMPANY HAS SEEN IN ITS FOOTPRINT SINCE 2009.

A. Since 2009, the Company has interconnected 30 new customer-owned substations to the transmission system. Seven of those 30 interconnections were completed in 2018.

The interconnection of new industrial plants and the expansion of existing industrial facilities has resulted in a 40% increase in the net load on CenterPoint Houston's transmission system between 2009 and 2018.



Significantly, the full load of the seven newly energized transmission customer interconnections is not entirely reflected in the 2018 net load value because industrial facilities tend to ramp up their load over a period of weeks or months after energization.

Q. **HAS THIS INDUSTRIAL GROWTH BEEN LIMITED TO AREAS THAT HAVE A HIGH CONCENTRATION OF TRANSMISSION INFRASTRUCTURE?**

A. No. Since the Company's last rate proceeding, CenterPoint Houston has experienced tremendous industrial growth not only within the well developed areas of our service territory, but also in geographic areas where transmission infrastructure is less concentrated. For example, in the 2012-2014 time frame, the Company saw explosive industrial growth of approximately 180 MW in the Mont

Belvieu area in the northeastern part of its footprint. Additionally, the Port of Freeport, which is on the Gulf Coast approximately 60 miles south of Houston, has recently experienced significant industrial development with a total demand of over 1000 MW. The largest contributor to the Freeport area growth is Freeport LNG with an expected demand of approximately 790 MW with the ability to self-serve approximately 82 MW of that load with onsite generation. The growth in these two areas, in turn, has required the Company to expand the breadth of its transmission system much like distribution operations must do to serve in new suburban developments.

Q. HOW HAVE THESE NEW, LESS DEVELOPED INDUSTRIAL SITES IMPACTED THE INVESTMENT MADE IN THE TRANSMISSION SYSTEM?

A. In order to serve new, less developed industrial sites, the Company must make significant capital investments in its transmission system. High Voltage load growth investment projects include building new transmission substations, transformer additions at existing substations, upgrading 69 kV lines to 138 kV, and rebuilding and reconductoring existing lines to handle the additional capacity.

Q. HOW HAVE GENERATION INTERCONNECTION REQUESTS IMPACTED THE INVESTMENT MADE IN THE TRANSMISSION SYSTEM SINCE 2009?

A. Since 2009, the Houston area has been impacted by generation retirement, including approximately 727 MW at NRG's SR Bertron facility, 371 MW at NRG Green's Bayou, and 280 MW at Capital Cogen, among others. As generation retires, the Company must rely more heavily on tie-lines to support the greater Houston area's load. Tie-lines, such as BVC, require considerable planning and capital investment but ultimately help the Company serve customers reliably and safely.

In addition, the Company has experienced an unprecedented increase in generation interconnection requests, especially from wind and solar generators. At the end of 2018, the Company had approximately 18 active Full Interconnection Studies underway related to new generation. These types of requests often require system upgrades or reconfigurations to respond to power flow shifts on the system.

Q. WHAT LOAD GROWTH PROJECTS HAVE BEEN NECESSARY SINCE THE COMPANY'S LAST RATE PROCEEDING?

A. Since the Company's last rate proceeding, CenterPoint Houston has invested approximately $1.51 billion in load growth projects including new substations, new transmission lines, new three-phase underground facilities, new power transformers and autotransformers, and upgrades to existing transmission, substation, and underground facilities. The need for new substations and new transmission lines, as well as other transmission system upgrades, are identified through the transmission and distribution planning process described in Ms. Bodden's testimony.

Q. PLEASE DISCUSS INVESTMENT IN CENTERPOINT HOUSTON'S SUBSTATIONS FROM 2010 THROUGH 2018.

A. Since the Company's last rate proceeding, CenterPoint Houston has built six distribution substations and six new transmission substations to keep up with load growth inside its footprint. This number does not include the two interconnecting switchyards that were built to interconnect new generation. Aside from building new substations, CenterPoint Houston has also addressed load growth by modifying existing substations and substation equipment in order to enhance our ability to serve increased load. These modifications include adding autotransformers at existing substations and upgrading existing autotransformers or other limiting equipment. Ms. Bodden's testimony details the transmission and distribution planning processes for determining the need for new substations to address load growth as well as the internal and external approval processes for new substations.

Q. DOES CENTERPOINT HOUSTON EXPECT LOAD GROWTH TO CONTINUE?

A. Yes. The Company plans to energize approximately six new customer substations between 2019 and the end of 2020 and will experience load expansion for at least three existing sites. These projects, which include publicly announced projects by Enterprise Products and Targa Resources, have an aggregate demand of approximately 350 MW. Transmission planning is also studying eight new customer load projects, with an aggregate demand of 880 MW, as well as the unprecedented number of generator interconnection requests.

Q. ARE INCREASING LEVELS OF CAPITAL INVESTMENT REQUIRED TO SUPPORT AND SERVE THE COMPANY'S LOAD GROWTH?

A. Yes. The Company will continue to invest in necessary infrastructure to safely and reliably serve all customers in its footprint.

C. **System Improvements**

Q. WHAT TYPES OF TRANSMISSION PROJECTS ARE INCLUDED IN THE CATEGORY OF SYSTEM IMPROVEMENTS?

A. CenterPoint Houston's transmission system has been delivering energy to customers for over 100 years, and the Company has facilities and equipment that have been installed throughout that time. Projects involving replacement of facilities or equipment typically occur when the facilities or equipment become obsolete or deteriorated, and therefore pose reliability or safety concerns. Replacement decisions are typically made based on an assessment of the condition of the facilities conducted either through monitoring and inspection programs or in response to outages.

Q. PLEASE DESCRIBE SOME OF THE TYPICAL ACTIVITIES INCLUDED IN THIS CATEGORY.

A. Transmission preventive maintenance projects involve replacement or modification of equipment that is identified through the five-year inspection and maintenance cycle or through reliability reporting and analysis for all transmission circuits. Substation corrective projects, such as the circuit breaker replacement program, involve replacement or modification of equipment identified through condition-based inspection or analysis of substation equipment. Control center modifications or replacement projects are based upon external requirements (typically ERCOT or NERC requirements) and upon ongoing assessments of system functionality.

An adequate inventory of spares for major equipment, such as transformers and breakers, is also kept in the event that long lead-time, major equipment fails or is damaged. Typically, this type of equipment requires lead times in excess of nine months to acquire and it is prudent to maintain a certain number of spares in reserve to replace failed equipment. Once placed into service, spare equipment is replaced as soon as practical to maintain an adequate inventory.

The Company has made several capital improvements to their substation facilities since 2009. For example, the Company has retrofitted several substations with an elevated substation design, based on coastal location, flood plain maps and our experience with Hurricanes Ike and Harvey, to account for storm surge and other types of flooding. New coastal substations are constructed such that flood-sensitive equipment is above the potential storm surge for a CAT 5 storm based on the NOAA storm surge inundation map while inland substations are designed with an elevation that considers flood plain maps. Additionally, the Company has invested in heightened physical security at all substations to reduce the risk of unauthorized access.

CenterPoint Houston's facilities must also be modified or relocated upon request. Often these requests are from governmental agencies and are related to road widening; water, road or rail crossing regulations; or other improvement or expansion projects. Responsibility for the costs of relocating transmission facilities typically is placed upon the requesting party unless the land rights of the requesting party indicate otherwise.

D. Restoration

Q. PLEASE GENERALLY DESCRIBE THE RESTORATION EFFORTS INCLUDED IN THIS CATEGORY.

A. The capital expenditures included in Restoration investment are the costs to restore transmission, substation, or Major Underground facilities after an extreme weather or other catastrophic event occurs. After these types of events occur, CenterPoint Houston moves quickly to restore service using emergency preparedness plans. Transmission Operations has an emergency operating material plan negotiated with vendor alliances to ensure that replacement structures, wire, hardware, and insulators are available on-hand before hurricane season and that replenishment of material is expedited should additional material be needed for restoration. This spare material is also used throughout the year, outside of hurricane season, for restoration after tornadoes, fires, or collisions.

Q. CAN YOU PROVIDE A DESCRIPTION OF HIGH VOLTAGE OPERATIONS' RESTORATION RESPONSE TO HURRICANE HARVEY?

A. After making landfall as a Category 4 storm near Port Aransas, Texas, Hurricane Harvey stalled, impacting south Texas, southeast Texas, and Louisiana for days. 51.88 inches of rainfall was registered in southeast Texas, breaking the single-storm record of 48 inches set in 1978. As a result of Harvey, 293 distribution circuits locked out, 4,494 distribution fuses went out, two transmission structures were completely destroyed, six transmission structures were badly damaged, eight substations were out of service and nine substations were inaccessible due to high water.

The most severe CenterPoint Houston substation flooding occurred at Memorial Substation, a distribution substation that serves 8,000 customers in West Houston. The Company made the difficult decision to shut down the substation after it was inundated with eight feet of water, which damaged equipment and created a dangerous situation. Committed to restoring power to the 4,800 customers who could not be served by neighboring substations, CenterPoint Houston constructed a temporary substation in less than a week. The temporary substation, named Vianney Memorial Substation, was located in the parking lot of St. John Vianney Catholic Church. Vianney Memorial Substation served customers in the area until Memorial Substation could be fully restored. To minimize impacts to the church, CenterPoint Houston installed extra tall structures to go over the tops of trees and placed them in flower beds to prevent damaging the newly paved parking lot. Construction and repairs to Memorial substation were completed in October 2018 and temporary substation Memorial Vianney was removed.

E. Operations and Support Investments

Q. PLEASE GENERALLY DESCRIBE THE TYPES OF CAPITAL EXPENDITURES INCLUDED IN THE CATEGORY OF OPERATIONS AND SUPPORT INVESTMENTS.

A. The capital expenditures included in operations and support investment include expenditures related to work locations, vehicles, and electrical equipment necessary to perform work on transmission and substation facilities. Expenditures related to work locations include modifications to offices and purchases of office equipment such as computers, printers, and copiers. Expenditures related to vehicles include service trucks, inspection vehicles, bucket trucks, trailers, and other construction equipment. Expenditures related to electrical equipment include equipment necessary to test and commission transmission and substation facilities such as Doble diagnostic testing equipment, relay test equipment, and meters.

Q. CAN YOU PROVIDE AN EXAMPLE OF AN OPERATIONS AND SUPPORT INVESTMENT?

A. Yes, the Company's Addicks Operations Center ("AOC") is considered an operations and support investment. AOC is a back-up control center for the transmission system which was built in 2015, costing approximately $175 million. As a result of an audit in late 2009/early 2010, NERC required ERCOT and the Local Control Centers, including CenterPoint Houston, to enter into a Joint Registration Organization or Coordinated Functional Registration. This required CenterPoint Houston to be registered as a limited Transmission Operator ("TOP"). As a limited TOP, NERC standard EOP-008-1, which requires TOPs to own and operate a back-up control center, became applicable to CenterPoint Houston. The Company negotiated an implementation plan which allowed five years for the construction of AOC. Construction of the facility was complete at the end of 2015 and TRE/NERC granted certification of the facility in early 2016.

Currently, all RTO training occurs at AOC which is staffed during normal business hours with trainers, NERC certified system controllers, and several support personnel. The Energy Management System ("EMS") at AOC has the same capabilities as the EMS at the primary control center. The process to transfer control of the BES from the primary control center to the back-up control center takes approximately four to six minutes.

Q. IS THE COMPANY REQUESTING A PRUDENCY DETERMINATION FOR THE ABOVE-REFERENCED CAPITAL PROJECTS?

A. Yes, the Company is requesting a prudency determination on all capital additions from January 1, 2010 through December 31, 2018.

Q. IS ALL OF THE CAPITAL INVESTMENT BOOKED TO PLANT AS ADJUSTED THROUGH DECEMBER 31, 2018 USED AND USEFUL IN PROVIDING UTILITY SERVICE?

A. Yes.

Q. IS ALL OF THE COMPANY'S TRANSMISSION CAPITAL INVESTMENT REASONABLE AND NECESSARY?

A. Yes. All of the Company's transmission capital investment was necessary to ensure a reliable transmission system that complies with applicable NERC standards and enable increased transfers across constrained transmission interfaces identified by ERCOT.

VI. PLANNING AND COST CONTROL

Q. HOW ARE HIGH VOLTAGE OPERATIONS CAPITAL EXPENDITURES ESTABLISHED, MONITORED, AND CONTROLLED?

A. In her testimony, Ms. Bodden explains both the external oversight of certain transmission and substation capital projects by ERCOT and/or the Commission and the internal process for inclusion of a project in the capital budget. These processes are in place to ensure that projects are consistent with CenterPoint Houston's policies and good utility practice. Since capital projects within High Voltage Operations range in size from a few thousand dollars to several hundred million dollars, there is also a range in the level of project controls used to monitor the capital spend. A project engineer is assigned to each High Voltage Operations capital project and the project's status and cost are reviewed on an ongoing basis during monthly schedule and budget meetings. Larger projects require a higher level of coordination and therefore need a full time project manager and more thorough project controls. Please see Ms. Bodden's testimony for additional detail on the Company's capital investment and O&M budget and cost control processes.

Q. CAN YOU PROVIDE ANY EXAMPLES OF HOW THE COMPANY'S PROCESS HAS RESULTED IN THE SUCCESSFUL EXECUTION OF NEEDED PROJECTS AT REASONABLE COSTS?

A. BVC, as discussed above in the interconnections section of the capital discussion, is an example of a high-dollar High Voltage Operations capital project that benefited from the use of additional project controls. BVC had a dedicated project manager, executive oversight committee comprised of both corporate and business unit leaders, and a dedicated master project scheduler. The project manager and master project scheduler developed a baseline schedule, held weekly project status reviews and monthly financial reviews, identified actual or potential risks to the schedule and budget, and created risk mitigation plans to help keep the project on track. During the planning phase, management developed detailed access and road use plans, materials receiving plans with designated lay down areas, permit acquisition, cross-utility coordination, and advanced outage scheduling. Project construction was broken into three sections and bid separately to increase cost competition and allow expedited construction since the project was on a tight timeline. Consistent with our core values, the Company had a dedicated safety representative in the field during construction to keep the team focused on working safely and efficiently. As a result, BVC was placed into service ahead of schedule and within the estimated budget.

VII. CONCLUSION

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. CenterPoint Houston's investment of approximately $3.0 billion, for transmission, substation, and Major Underground capital investments incurred from January 1, 2010 through December 31, 2018 is reasonable and necessary to provide electric service in the ERCOT Region. During the 2010 to 2018 period, CenterPoint Houston invested in transmission, substation, and Major Underground facilities to interconnect new generation, build transmission ties to import power, upgrade facilities to accommodate load growth, restore service after catastrophic events, replace or modify aging infrastructure, and increase the efficiency of daily operation of the transmission system.

Additionally, the O&M expenses incurred by the High Voltage Operations division during the test year are reasonable and necessary expenses that should be recovered in the Company's rates. My testimony demonstrates that the High Voltage Operations division is properly structured in order to accomplish the goal of providing safe and reliable electric service at a reasonable cost. Costs associated with this organization are effectively managed and maintained at reasonable levels through the entire process of business planning, budget plan review and ongoing budget plan monitoring. Moreover, the activities performed by the High Voltage Operations division are a reasonable and necessary part of providing electric utility service.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

STATE OF TEXAS §
§
COUNTY OF HARRIS §

AFFIDAVIT OF MARTIN W. NARENDORF JR.

BEFORE ME, the undersigned authority, on this day personally appeared Martin W. Narendorf Jr. who having been placed under oath by me did depose as follows:

1. "My name is Martin W. Narendorf Jr.. I am of sound mind and capable of making this affidavit. The facts stated herein are true and correct based upon my personal knowledge.

2. I have prepared the foregoing Direct Testimony and the information contained in this document is true and correct to the best of my knowledge."

Further affiant sayeth not.

Martin W. Narendorf Jr.

SUBSCRIBED AND SWORN TO BEFORE ME by the said Martin W. Narendorf Jr. on this 15th day of March, 2019.

Alice S Hart
Notary Public in and for the State of Texas

My commission expires: 07/17/2019

ALICE S HART
Notary Public, State of Texas
My Commission Expires 07-17-2019

MARTIN J. NARENDORF WORKPAPERS:

- WP MWN-1 Mont_Belvieu_Upgrades_020312.pdf
- WP MWN-2 2012_NW_Houston_Reliability.pdf
- WP MWN-3 Jones Creek RPG 07012014.pdf
- WP MWN-4 Track Equipment 2014.pdf
- WP MWN-5 Qualitrol TSDOS 2015.pdf
- WP MWN-6 TOV_ANALYSIS_Draft_20181201.pdf
- WP MWN-7 e-LoadForecast (003).pdf
- WP MWN-8 Business Journal Article on Mont Belvieu Expansions.pdf
- WP MWN-9 Houston Chronicle Mont Belvieu and Pipeline Expansions.pdf
- WP MWN-10 FIS System Map.pdf
- WP MWN-11 Annual System Net Load.pdf
- WP MWN-11 Annual System Net Load.xlsx

Mont Belvieu Area Upgrade

February 3, 2012

Prepared by:

CenterPoint Energy Houston Electric, LLC (CenterPoint Energy)

Executive Summary

The Mont Belvieu area of CenterPoint Energy's service territory is experiencing a significant increase in industrial customer load interconnected to the 138 kV transmission system. The Mont Belvieu area is located in the far Northeastern part of CenterPoint Energy's transmission system as shown in Figure 1. This area has a large concentration of existing load (approximately 426 MW) that is served by three 138 kV transmission lines. CenterPoint Energy is currently expecting an increase in this load of approximately 180 MW over the next few years.

CenterPoint Energy studied numerous scenarios to resolve line overloads and voltage violations associated with this increase in load and narrowed the solution to two options. Both of these options alleviate the loading and voltage violations as well as limit the number of customer-owned two-line loop breaker substations to no more than three between CenterPoint Energy major substations in accordance with CenterPoint Energy's Transmission System Design Criteria. The lowest cost option of constructing a new 345 kV / 138 kV substation with an 800 MVA autotransformer is recommended to provide a robust, reliable design and to satisfy CenterPoint Energy's Transmission System Design Criteria. The recommended option is estimated to cost $42,075,000 and is expected to be completed by summer peak 2014, which takes into consideration the typical lead times necessary to implement the proposed projects, including ERCOT review and approval, and materials and construction lead times.

Assumptions

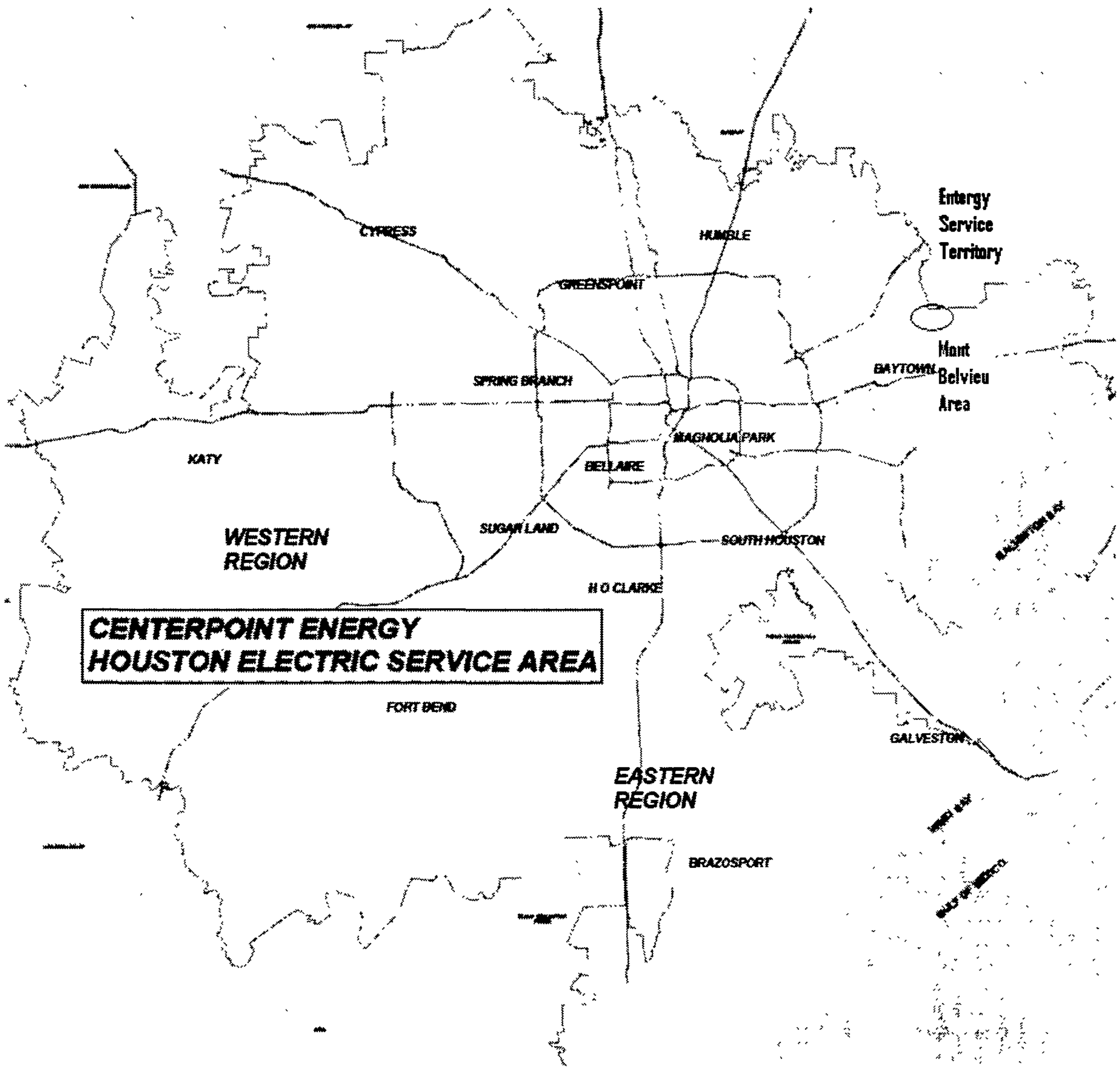
The following study is based on the load forecast, generation pattern, and network topology projected for 2013, 2014, and 2016 summer peak conditions contained in the ERCOT Steady-State Working Group base cases posted on April 28, 2011. Base Cases used:

2013 Summer Peak Case – CNP_ss13SUM1eco04282011.sav

2014 Summer Peak Case – CNP_ss14SUM1eco04282011.sav

2016 Summer Peak Case – CNP_ss16SUM1eco04282011.sav

Figure 1 – Overview of Mont Belvieu Area Location



Background

Recent industrial customer activity in the Mont Belvieu area has resulted in an influx of 138 kV load in this remote portion of the CenterPoint Energy service area. Expected load additions include 20 MVA at the existing WARVUE Substation, 10 MVA load addition at the existing CITIES Substation, a new industrial customer-owned NORTON Substation with maximum total load of 97.9 MVA, and a new industrial customer-owned WINFRE Substation with maximum total load of 65 MVA. The addition of this load leads to a number of single and common mode contingency conditions that cause overloads and low voltages that violate CenterPoint Energy's Transmission System Design Criteria. Additionally, the new NORTON and WINFRE Substations are proposed as two-line loop breaker substations. The existing circuit near these substations already has three customer-owned two-line loop breaker substations, which is already at the recommended limit specified in the CenterPoint Energy Transmission System Design Criteria. Therefore, CenterPoint Energy evaluated alternatives to relieve voltage and loading criteria violations as well as maintain alignment with the design criterion related to limiting the number of consecutive two-line loop breaker substations.

CenterPoint Energy operational personnel also reviewed the existing circuit configuration and determined that a scheduled outage of any segment of existing 138 kV Crosby – BENDER – DUNCAN – BARHIL – HACHER – ENPROD – CITIES – BRINE_ – Mont Belvieu circuit 86 potentially results in loss of multiple customer substation loads, low voltages or overloads for the next contingency. An optimal solution to resolve the long term loading and reliability issues in the Mont Belvieu area and this operational concern is needed.

Industrial Customer Changes

1. *Existing ENPROD 138 kV Substation Conversion in 2012*

Three existing industrial customer two-line loop breaker substations are currently served on the 138 kV Crosby – Mont Belvieu circuit 86. ENPROD is a customer-owned substation that is currently served by an unbreakered loop tap on this circuit. The customer is seeking to convert ENPROD to a two-line loop breaker substation for reliability purposes in early 2012. This will result in a fourth two-line loop breaker substation customer on 138 kV Crosby – Mont Belvieu circuit 86. CenterPoint Energy's Transmission System Design Criteria Section VI states:

> *"To the extent that it is reasonably and economically practical, CNP seeks to limit the number of two-line, loop breaker substations on a transmission line segment between major (3 or more line terminals) substations to three or less. This is due to relay considerations and to limit the exposure of multiple two-line, loop-breaker substations to separation from the CNP transmission system"*

It is prudent to resolve this issue in tandem with any reliability upgrades to the Mont Belvieu area in the near future.

2. *Existing WARVUE 138 kV Substation Load Addition First Quarter 2012*

The customer owning WARVUE Substation is proceeding with an expansion of the substation to add an additional 20 MVA of load in the first quarter of 2012.

3. *Existing CITIES 138 kV Substation Load Addition First Quarter 2012*

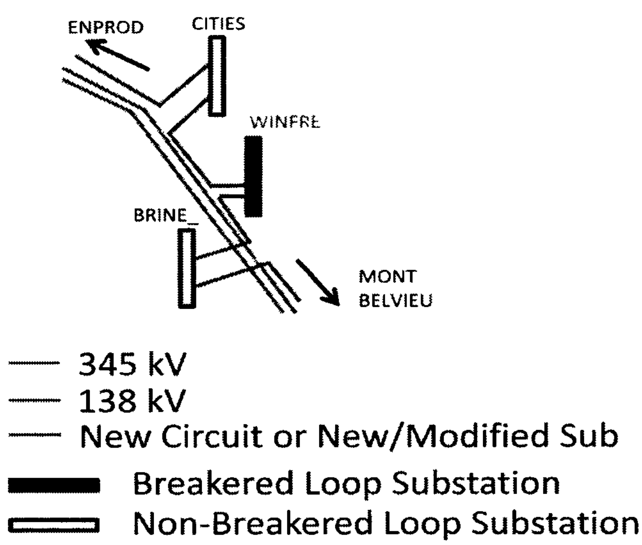
The customer owning CITIES Substation is proceeding with an expansion of the substation to add an additional 10 MVA of load in the first quarter of 2012.

4. *New Customer Substation – WINFRE Third Quarter 2012*

A new two-line loop breaker customer-owned substation is being built in the Mont Belvieu area. The new WINFRE Substation will be connected by breaking the existing circuit 86 connection between CITIES and BRINE_ Substations and looping circuit 86 to WINFRE Substation located adjacent to the existing transmission line right–of–way.

The customer constructing WINFRE has requested an energization date of September 2012 and will introduce 35 MVA of load at the time the substation is energized. The customer plans to remove its BRINE_ 138 kV substation and increase load at the new substation by 30 MVA prior to 2014 peak for a total load of 65 MVA. This proposal adds a fifth two-line loop breaker substation on 138 kV Crosby – Mont Belvieu circuit 86. It is prudent to resolve this issue in tandem with any reliability upgrades to the Mont Belvieu area in the near future.

Figure 2 – WINFRE Connection

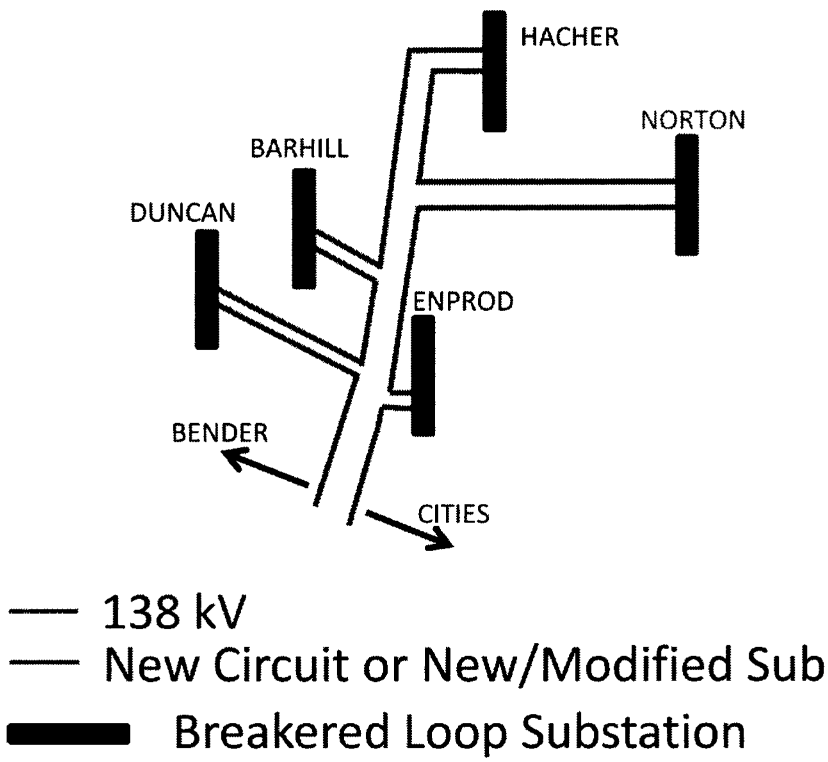


5. *New Customer Substation – NORTON Fourth Quarter 2012*

A new two-line loop breaker customer-owned substation is being built in the Mont Belvieu area, referred to as NORTON Substation. The total substation load is 97.9 MVA, to be added in stages from energization date in fourth quarter 2012 through 2016.

NORTON Substation will be connected by breaking the circuit 86 connections between ENPROD and HACHER Substations and looping circuit 86 to the substation. The line extension is less than one mile in length. This configuration adds a sixth two-line loop breaker substation to 138 kV Crosby – Mont Belvieu circuit 86. It is prudent to resolve this issue in tandem with any reliability upgrades to the Mont Belvieu area in the near future.

Figure 3 – NORTON Connection



Mont Belvieu Area Industrial Customer Changes – Full Compilation

The previous section of this study detailed individual industrial customer changes that were proposed in the Mont Belvieu area. CenterPoint Energy studied the compilation of all of these changes to the network to evaluate the total impact and choose the most robust solution. Each industrial customer upgrade and new facility was implemented according to the latest customer-provided information.

- By 2013 Summer Peak
    - 2013 Summer Peak Base Case
    - WARVUE Expansion – Load increased by 20 MVA
    - CITIES Expansion – Load increased by 10 MVA
    - New NORTON Substation – New substation total load 53 MVA
    - Mont Belvieu Load – Reduce load at existing substation by 7 MVA
    - New WINFRE Substation – New substation total load 35 MVA
- By 2014 Summer Peak
    - 2014 Summer Peak Base Case
    - WARVUE Expansion – Load increased by 20 MVA
    - CITIES Expansion – Load increased by 10 MVA
    - New NORTON Substation – New substation total load 53 MVA
    - Mont Belvieu Load – Reduce load at existing substation by 7 MVA
    - New WINFRE Substation – New substation total load 65 MVA
    - Remove BRINE_ Substation
- By 2016 Summer Peak
    - 2016 Summer Peak Base Case
    - WARVUE Expansion – Load increased by 20 MVA
    - CITIES Expansion – Load increased by 10 MVA
    - New NORTON Substation – New substation total load 98 MVA
    - Mont Belvieu Load – Reduce load at existing substation by 7 MVA
    - New WINFRE Substation – New substation total load 65 MVA
    - Remove BRINE_ Substation

CenterPoint Energy's Transmission System Design Criteria details internal requirements for planning purposes. For NERC Category B conditions, a transmission network element should not exceed the continuous rating (Rate A) and for NERC Category C conditions, a transmission network element should not exceed the 2-hour emergency rating (Rate B). For transmission buses, during NERC Category B conditions, all voltages should remain within a range of 95% to 105% of nominal voltage and during NERC Category C conditions, all voltages should remain within a range of 92% to 105% of nominal voltage. Numerous branch loading and low voltage violations were created by these configurations as detailed in Table 1 and Table 2.

Table 1 – Mont Belvieu Area Full Compilation Branch Loading

CKT	Overloaded Line	Contingency	2013 Base Case	2013 with Customer Projects	2014 Base Case	2014 with Customer Projects	2016 Base Case	2016 with Customer Projects
66	BAYTWN__138C-BAYTWN668060	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	<100%	<100%	<100%	<100%	<100%	103.3% (526 MVA)
84	CEDAR84_8050 - WARVUE__138A	CEDARP__138C - CHEV___138X CKT 86	<95%	<95%	<95%	96.1% (440 MVA)	<95%	101.7% (440 MVA)
84	CEDARP__138C - CEDAR84_8050	CEDARP__138C - CHEV___138X CKT 86	<95%	101.4% (440 MVA)	<95%	104.6% (440 MVA)	<95%	110.3% (440 MVA)
86	CEDARP__138C - CHEV___138X	CEDARP__138C - WARVUE__138A CKT 84	<95%	<95%	<95%	97.6% (430 MVA)	<95%	103.1% (430 MVA)
86	BARHIL__138A - DUNCAN__138A	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	<100%	108% (478 MVA)	<100%	114.9% (478 MVA)	<100%	130.6% (478 MVA)
86	BARHIL_138A-HACHER__138X	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	<100%	103 2% (478 MVA)	<100%	110.1% (478 MVA)	<100%	125.6% (478 MVA)
86	BENDER_86-CROSBY__138A	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	<100%	118.4% (469 MVA)	<100%	125.6% (469 MVA)	<100%	141.8% (469 MVA)
86	DUNCAN__138A - BENDER_86	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	<100%	117 4% (469 MVA)	<100%	124.5% (469 MVA)	<100%	140.7% (469 MVA)
86	NORTON__138 - HACHER__138X	CEDARP__138C - WARVUE__138A CKT 84 CEDARP__138C - CHEV___138X CKT 86	N/A	<100%	N/A	<100%	N/A	114.9% (478 MVA)

Table 2 – Mont Belvieu Area Voltage Violations

Bus	Contingency	2013 Base Case	2013 with Customer Projects	2014 Base Case	2014 with Customer Projects	2016 Base Case	2016 with Customer Projects
CHEV___138X	CEDARP__138C - WARVUE__138A CKT 84	0.926	0.854	0.925	0.842	0.923	0.811
	CEDARP__138C - CHEV___138X CKT 86						
EAGLE___138A	CEDARP__138C - WARVUE__138A CKT 84	0.929	0.871	0.928	0.862	0.926	0.833
	CEDARP__138C - CHEV___138X CKT 86						
NORTON__138	CEDARP__138C - WARVUE__138A CKT 84	N/A	0.898	N/A	0.889	N/A	0.861
	CEDARP__138C - CHEV___138X CKT 86						
MT_BEL__138A	CEDARP__138C - WARVUE__138A CKT 84	0.930	0.858	0.929	0.846	0.927	0.815
	CEDARP__138C - CHEV___138X CKT 86						
WARVUE__138A	CEDARP__138C - WARVUE__138A CKT 84	0.930	0.858	0.929	0.846	0.927	0.815
	CEDARP__138C - CHEV___138X CKT 86						
BARHIL__138A	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.909	>.93	0.900	>.93	0.874
	CEDARP__138C- CHEV___138X CKT 86						
BENDER_86	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.928	>.93	0.919	>.93	0.897
	CEDARP__138C - CHEV___138X CKT 86						
BRINE___138A	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.867	>.93	[redacted]	>.93	[redacted]
	CEDARP__138C - CHEV___138X CKT 86						
CITIES__138X	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.878	>.93	0.865	>.93	0.836
	CEDARP__138C - CHEV___138X CKT 86						
DUNCAN__138A	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.913	>.93	0.903	>.93	0.878
	CEDARP__138C - CHEV___138X CKT 86						
ENPROD__8000	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.884	>.93	0.872	>.93	0.843
	CEDARP__138C - CHEV___138X CKT 86						
WINFRE__138	CEDARP__138C - WARVUE__138A CKT 84	N/A	0.872	N/A	0.859	N/A	0.829
	CEDARP__138C - CHEV___138X CKT 86						
HACHER__138X	CEDARP__138C - WARVUE__138A CKT 84	>.93	0.901	>.93	0.890	>.93	0.863
	CEDARP__138C - CHEV___138X CKT 86						

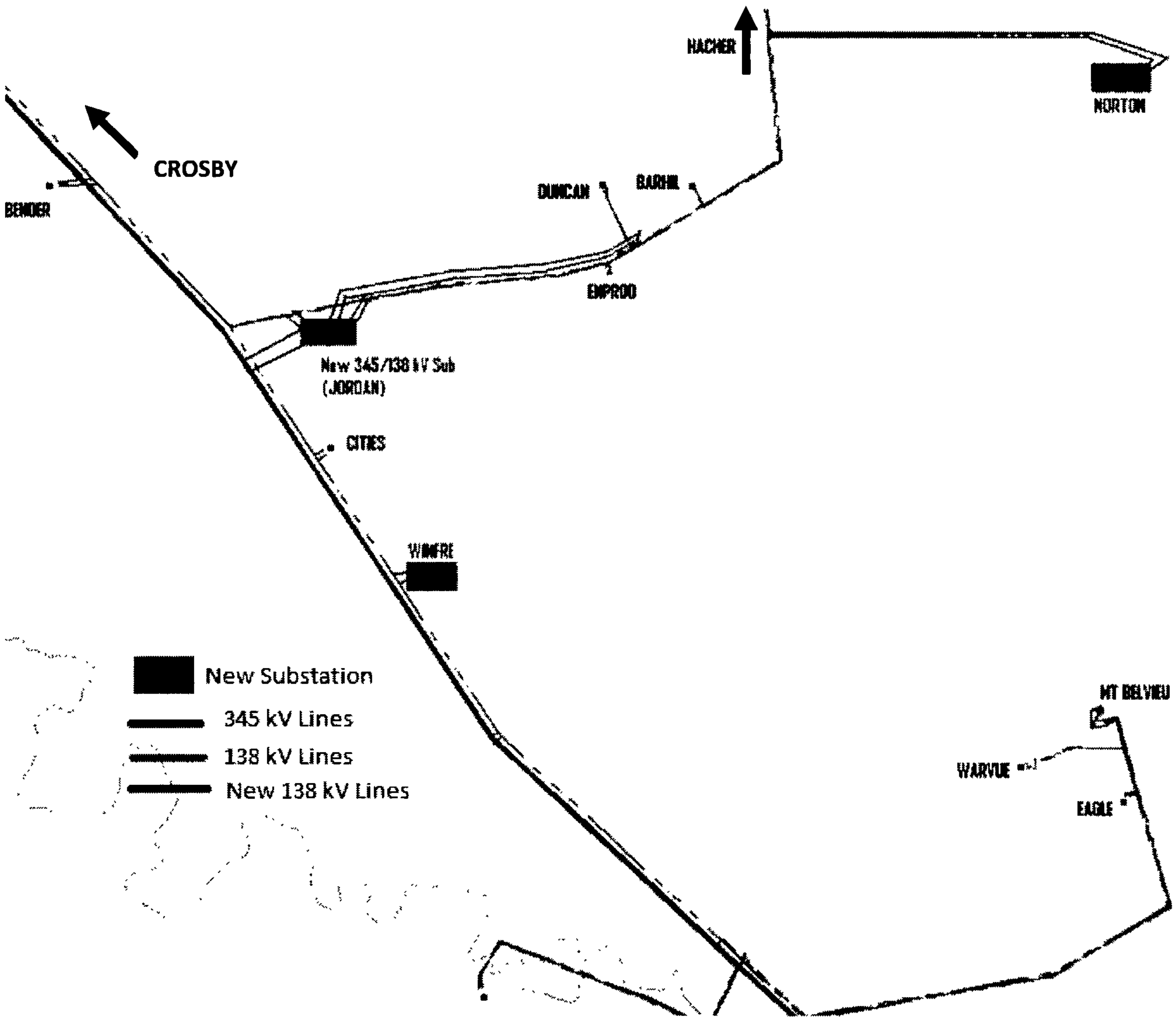
The large number of branch overloads and low voltages due to single and common mode contingencies support the need for CenterPoint Energy to study the effects of introducing additional transmission capacity to the Mont Belvieu area to support the growing load and maintain reliability.

Option 1 – Add New 345/138 kV Substation with 800 MVA Autotransformer

Transmission Planning studied the addition of a new 345/138 kV substation with an 800 MVA autotransformer in an effort to provide a solution to the growing load in the Mont Belvieu area.

A large amount of industrial customer transmission load in the Mont Belvieu area is concentrated on a loop segment of 138 kV circuit 86 between CenterPoint Energy major breakered substations Crosby and Mont Belvieu. Option 1 involves building a new 345/138 kV substation (Jordan) with an 800 MVA autotransformer, initially with two 345 kV line positions and six 138 kV line positions, approximately 0.4 miles from a main 345/138 kV transmission right—of—way (ROW). The substation would be designed to be expandable for additional 345 kV line positions, 138 kV line positions, and another autotransformer. Four of the six 138 kV line positions are for looping the existing circuits BENDER – DUNCAN and ENPROD – CITIES into the new substation. The two remaining 138 kV line positions will be connected to two new circuits on a new 0.8 mile double circuit transmission line running parallel to the existing 138 kV transmission line serving DUNCAN and extending to Tower #15016 near DUNCAN. This configuration solves the overloads and voltage violations due to single and common mode contingencies while also satisfying CenterPoint Energy's Transmission System Design Criteria by limiting the customer-owned two-line loop breaker substations between major breakered CenterPoint Energy owned substations to three. Additionally, the operational concern inherent in the existing topology is alleviated by the addition of the Jordan Substation. The 138 kV facilities and 345/138 kV autotransformer provide additional support to the 138 kV loads in the Mont Belvieu area. Figure 4 gives a geographical overview of Option 1 after completion of all projects in 2014. Table 3 lists the cost estimates of each subproject of Option 1 and the estimated completion date of each sub-project. Figures 5-7 show electrical one-line representations of the transmission system for a progression of the existing configuration with the Option 1 configuration expected for completion by summer peak 2014.

Figure 4 – Mont Belvieu Area with Option 1



The proposed project timeline and associated costs are shown below.

Table 3 – Timeline and Cost Estimates for Option 1

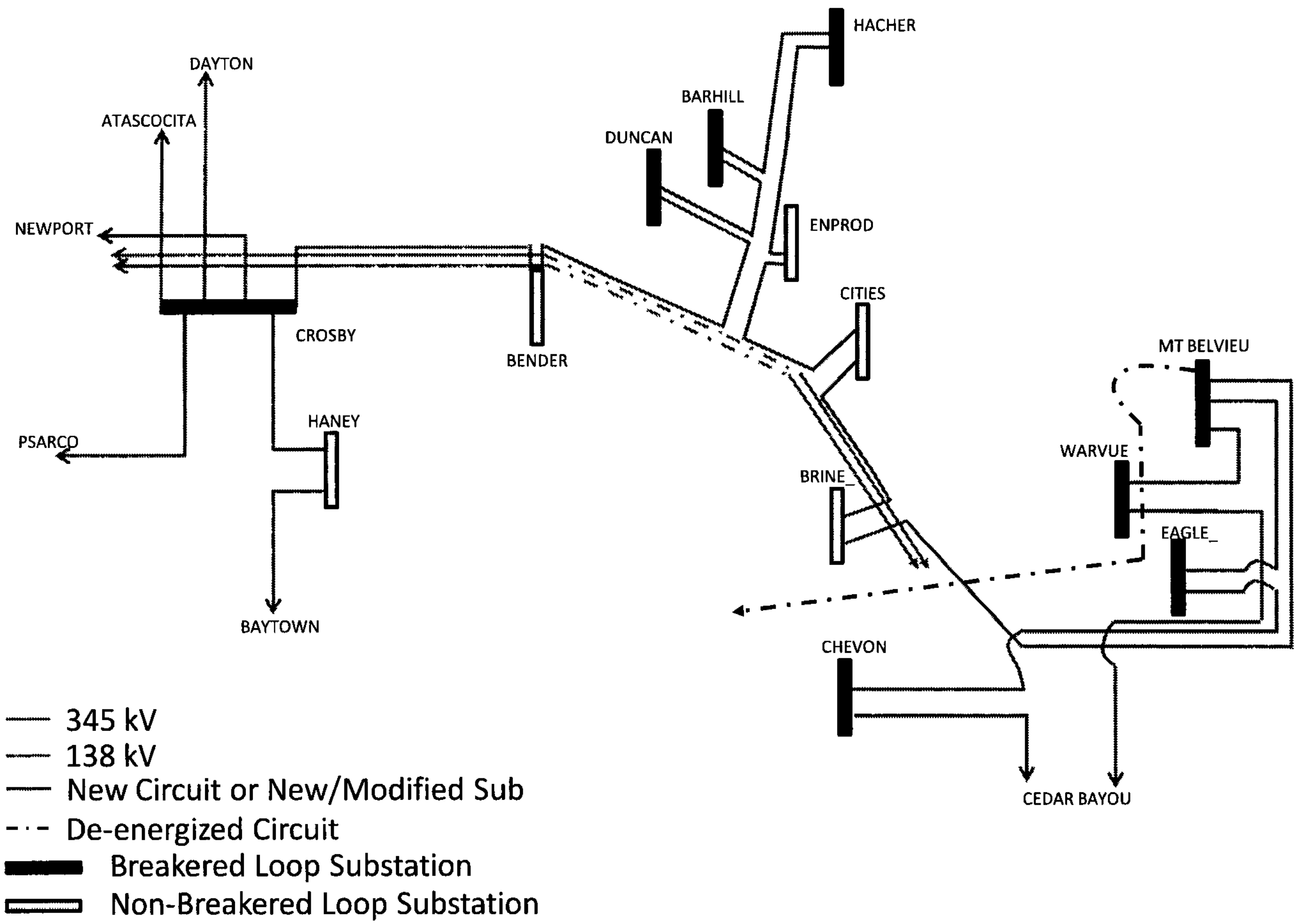
345/138 kV Substation with 800 MVA Autotransformer

Before Peak	Description	Transmission Costs	Substation Costs
2013	**Crosby - BENDER 138 kV circuit 86 D2** – Partial rebuild and upgrade 6.28 mile portion of 2-927 ACAR and upgrade substation equipment at Crosby to achieve a rating of at least 440 MVA continuous and 561 MVA emergency.	$2,950,000	$245,000
2013	**BENDER - DUNCAN 138 kV circuit 86 D1** - Thermal uprate 0.53 mile portion of 2-927 ACAR to achieve a rating of at least 440 MVA continuous and 561 MVA emergency.	$10,000	$0
2013	Install a 74.4 MVAR Cap Bank at Mont Belvieu 138 kV substation.	$0	$1,100,000
2014	Build new 345/138 kV substation Jordan	$0	$27,260,000
2014	Install 345/138 kV 800 MVA autotransformer at Jordan.	$0	In Above
2014	Loop 345 kV ckt 99 North Belt to Cedar Bayou into new 345 kV Jordan Substation.	$3,250,000	$240,000
2014	Loop 138 kV BENDER to DUNCAN ckt 86 and 138 kV ENPROD to CITIES ckt 86 to 138 kV positions at new Jordan Substation. BENDER to Jordan conductor rating at least 382 MVA continuous and at least 469 MVA emergency. Jordan to CITIES conductor rating at least 382 MVA continuous and at least 469 MVA emergency. ENPROD to Jordan conductor rating at least 440 MVA continuous and at least 562 MVA emergency. Jordan to DUNCAN conductor rating at least 440 MVA continuous and at least 562 MVA emergency.	$1,460,000	$60,000
2014	Build double circuit 138 kV transmission line adjacent to existing double circuit line approximately 0.87 miles from new 345/138 kV Jordan Substation to Tower #15016. Conductor rating on new double circuit at least 440 MVA continuous and at least 562 MVA emergency. At tower #15016, interface new parallel double circuit with existing conductor such that one 138 kV circuit from Jordan Substation interfaces with existing conductor to BARHIL Substation and remaining 138 kV circuit interfaces with existing conductor to NORTON Substation. Between Tower #15015 and Tower #15016 disconnect existing 138 kV circuits: DUNCAN - BARHIL circuit 86 and ENPROD – NORTON circuit 86. Loop the circuit out of DUNCAN Substation, formerly to BARHIL, back to ENPROD Substation at Tower #15015 using existing circuit. Minimum conductor rating of new connection is 440 MVA continuous and 562 MVA emergency.	$5,500,000	$0
SUB-TOTAL		**$13,170,000**	**$28,905,000**
TOTAL		**$42,075,000**	

Sequencing of Option 1 Projects

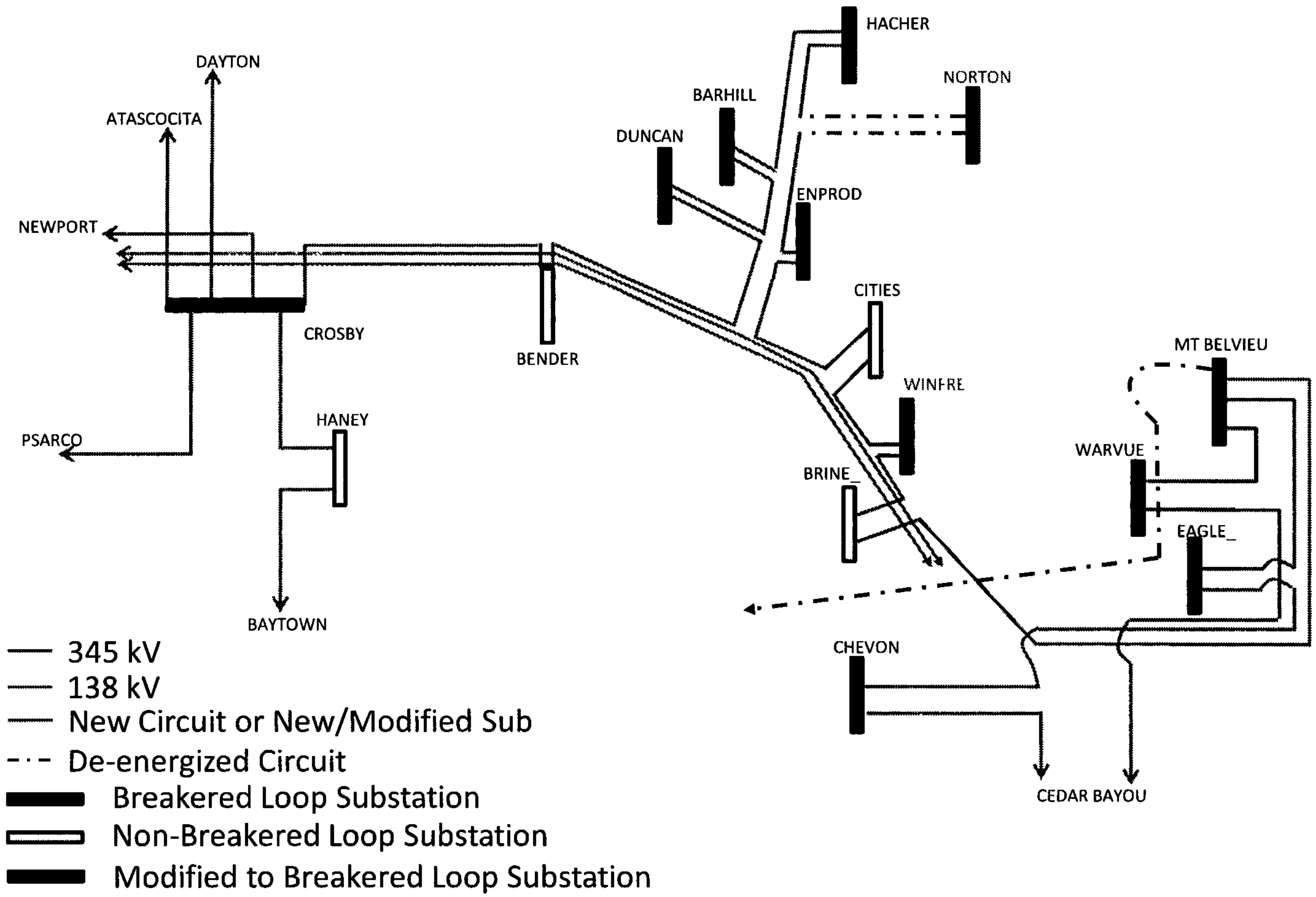
The existing configuration in the Mont Belvieu area is shown below in Figure 5.

Figure 5 – Existing Configuration Mont Belvieu Area



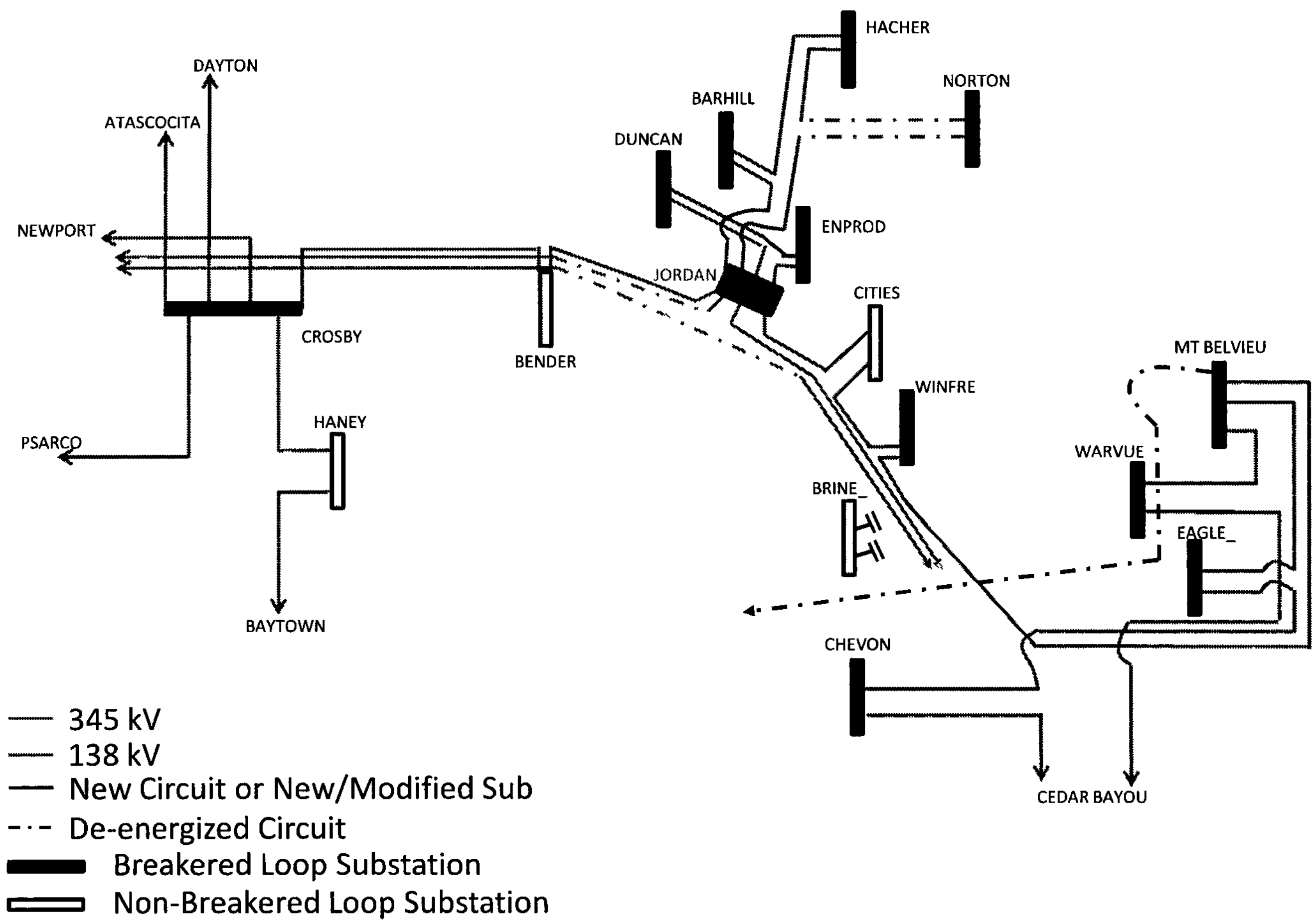
The Mont Belvieu area configuration by 2013 Peak of Option 1 is shown below in Figure 6.

Figure 6 – Option 1 Upgrades by 2013 Peak



The Mont Belvieu area configuration by 2014 Peak of Option 1 is shown below in Figure 7.

Figure 7 – Option 1 Upgrades by 2014 Peak



CenterPoint Energy anticipates that the 345/138 kV Jordan Substation with autotransformer and circuit reconfigurations can be completed prior to the 2014 summer peak as detailed in Table 3 and illustrated in Figure 7, subject to ERCOT review and acquisition of necessary property. The total cost of these system upgrades is estimated at $42,075,000. There are no line overloads or voltage violations due to single or common mode contingencies in the area after construction of these transmission facilities. Note that when WINFRE and NORTON eventually come on-line along with the ENPROD upgrade there will temporarily be three additive two-line loop breaker substations beyond the recommended limit prior to the completion of Jordan Substation in 2014.

Option 2 – New Three-Line Breaker Substation and 138 kV Circuit in Mont Belvieu Area

Transmission Planning studied an alternative scenario that solves the Mont Belvieu area reliability and line loading issues through the installation of a new 138 kV three-line breakered substation and new 138 kV Crosby – Mont Belvieu circuit. This option includes building a three-line breakered switching substation between Crosby Substation and Mont Belvieu Substation and connecting the switching substation from both the north and south. The north circuit would be a double circuit looping off the industrial customer loop between ENPROD and CITIES Substations, and the south circuit would be a single circuit that would interface with a dormant 69 kV circuit that would require rebuilding as a new 138 kV feed to Mont Belvieu Substation. In addition to this three-line breakered substation, circuit reconfigurations similar to Option 1 are needed to limit the number of two-line loop-breaker substations between CenterPoint Energy major substations. In order to meet the increased loading demand on the system, numerous transmission upgrades must be performed including a new circuit from Crosby Substation to Mont Belvieu Substation utilizing an open circuit position on the tower line currently carrying 138 kV Crosby to Mont Belvieu circuit 86. The operational concern inherent in the existing topology is alleviated by the new topology in the Option 2 configuration. The 138 kV switching station breaks up the long string of industrial customers and the additional 138 kV circuit provides an additional feed to the Mont Belvieu area.

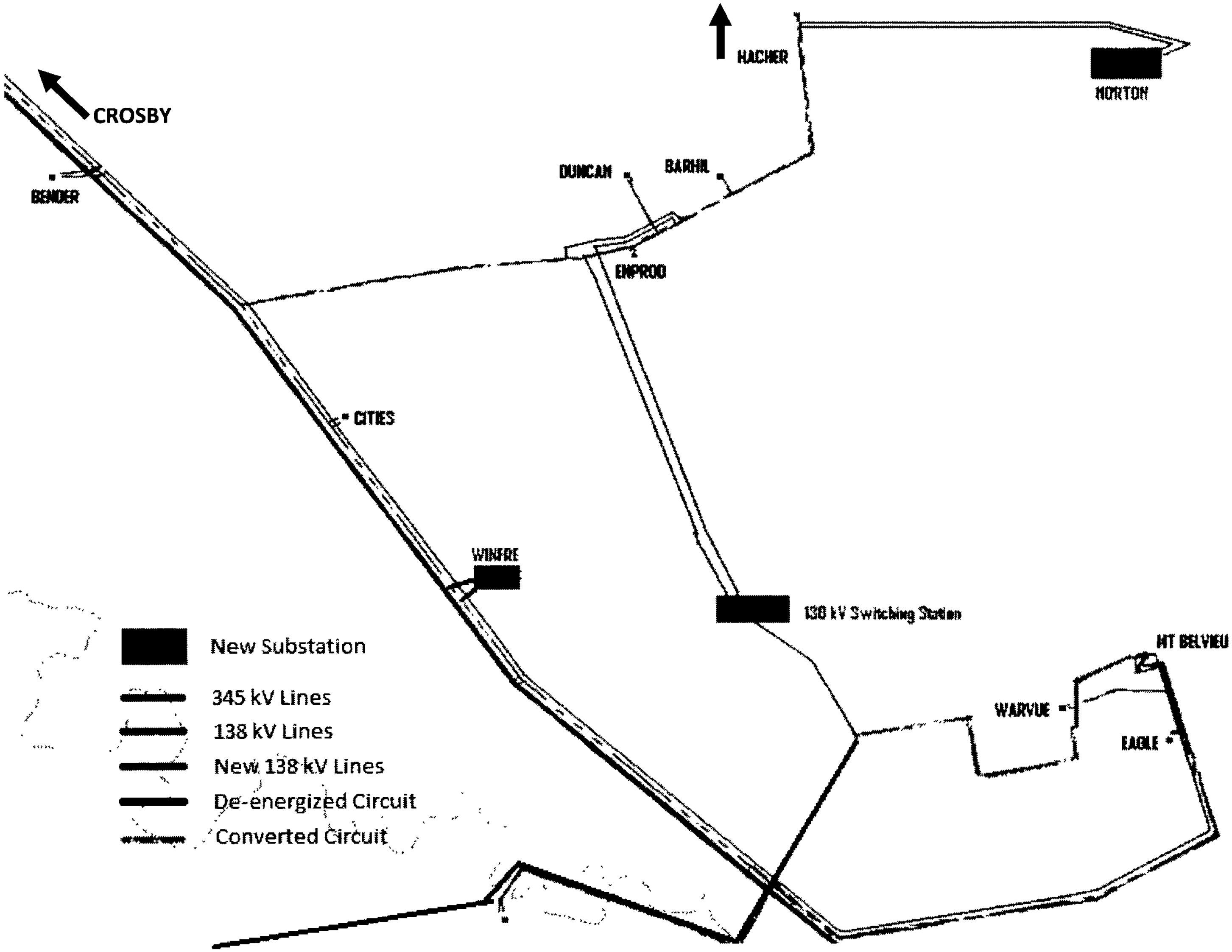
Table 4 – Timeline and Cost Estimates for Option 2

Option 2 - 138 kV 3 Position Substation and New Circuit CROSBY - MONT BELVIEU

Before Peak	Description	Transmission Costs	Substation Costs
2013	**Cedar Bayou Plant – Cedar Bayou Distribution tap 138 kV circuit 84 D1** – Upgrade to a rating of at least 526 MVA continuous and 600 MVA emergency.	$800,000	$100,000
2013	**Crosby - BENDER 138 kV circuit 86 D2** – Partial rebuild and upgrade 6.28 mile portion of 2-927 ACAR and upgrade substation equipment at Crosby to achieve a rating of at least 440 MVA continuous and 561 MVA emergency..	$2,950,000	$245,000
2013	**BENDER - DUNCAN 138 kV circuit 86 D1** – Upgrade to a rating of at least 440 MVA continuous and 561 MVA emergency.	$10,000	$0
2013	Install a 74.4 MVAR Cap Bank at Mont Belvieu 138 kV substation.	$0	$1,100,000
2014	Expand Mont Belvieu for a fourth and fifth 138 kV circuit position.	$0	$2,915,000
2014	Expand Crosby Substation for additional 138 kV circuit.	$0	$1,220,000
2014	Build CenterPoint Energy 138 kV switching substation.	$0	$8,000,000
2014	Loop new 138 kV switching station 0.9 miles off of existing 138 kV ENPROD – CITIES circuit 86 0.1 miles southwest of ENPROD next to the Transmission ROW. New 138 kV switching station - ENPROD conductor rating of at least 440 MVA continuous and at least 562 MVA emergency. New 138 kV switching station - CITIES conductor rating of at least 382 MVA continuous and 469 MVA emergency.	$3,200,000	$60,000
2014	Expand existing double circuit tower easement near ENPROD to include another double circuit heading northeast for approximately 0.2 miles with ratings of at least 440 MVA continuous and 562 MVA emergency for each conductor. Reconfigure the BENDER - DUNCAN circuit to become BENDER – BARHIL utilizing a position on new double circuit to cross existing conductor to DUNCAN. With the remaining open position of the new double circuit, connect NORTON to 138 kV switching station. Remaining circuit from WINFRE in the ENPROD area to connect to existing circuit to DUNCAN. Remaining circuit to DUNCAN reconfigured to connect to ENPROD.	$2,300,000	$100,000
2014	Utilize open position on existing 138 kV structures to connect new Crosby circuit to existing circuit to BARHIL at Tower #15003. Continue installation of new conductor on open circuit position from Tower #15003 existing connection from ENPROD to Mont Belvieu on open position. Existing 138 kV circuit 86 conductor should now connect BENDER to CITIES.	$4,000,000	$0
2014	Build 138kV single circuit from new 138 kV switching station 0.9 miles south towards existing dormant 69 kV structures. Conductor rating of at least 340 MVA continuous and emergency.	$2,000,000	$0
2014	Re-build 69 kV circuit for a single 138 kV service from Tower #15445 to Mont Belvieu, approximately 1.12 miles. Conductor rating of at least 340 MVA continuous and emergency.	$4,100,000	$0
2014	**Cedar Bayou Plant - CHEVON 138 kV circuit 86 A** - Reconductor 8.38 miles of existing circuit to achieve a rating of at least 500 MVA continuous and emergency. Upgrade Cedar Bayou Plant Substation rating to at least 500 MVA continuous and emergency.	$3,200,000	$95,000
2014	Thermal uprate 0.42 miles of 2-927ACAR currently 138 kV circuit 86 C-3 ENPROD - CITIES.	$0	$0

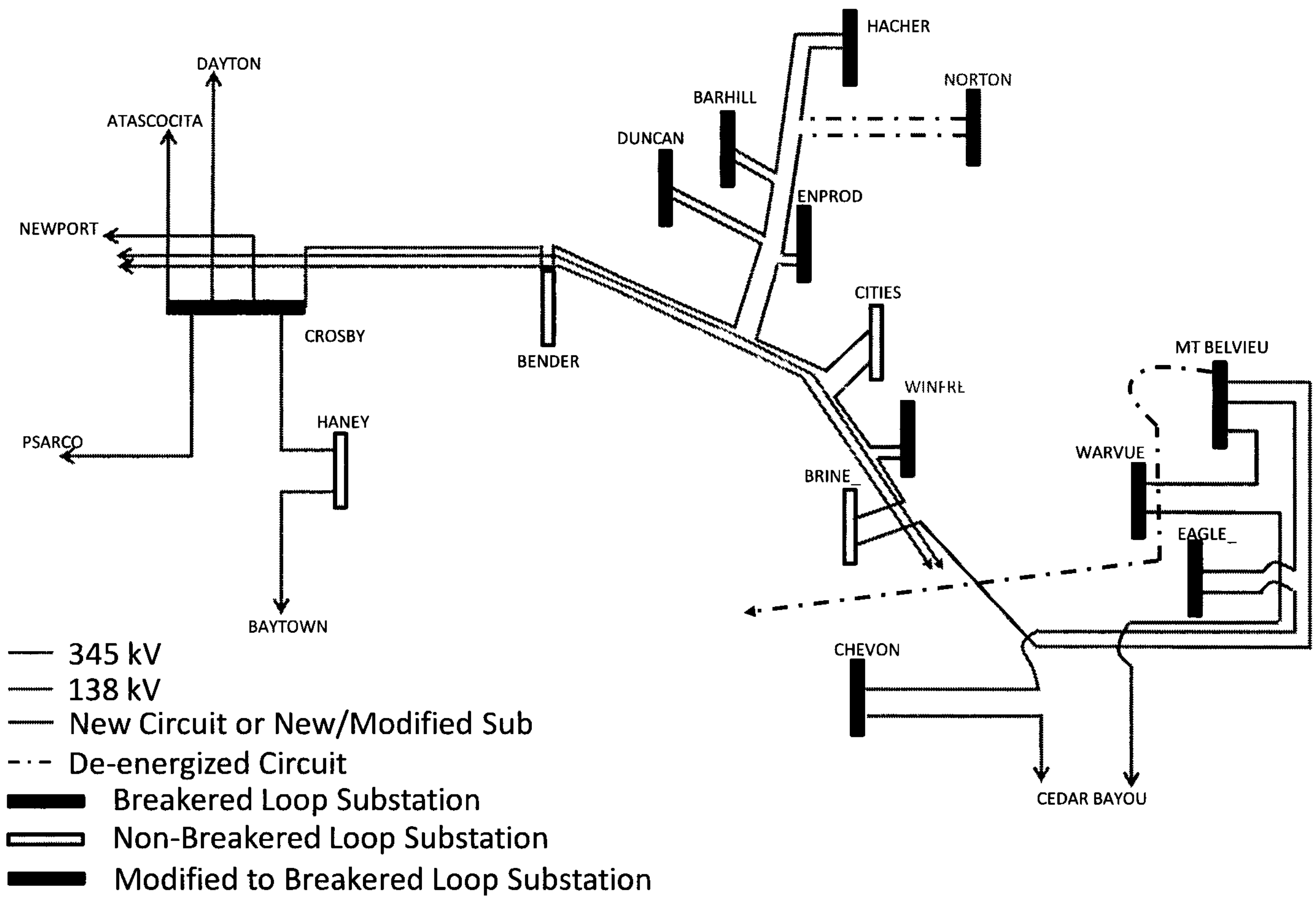
2014	Upgrade customer-owned CHEVON Substation equipment to achieve a rating of at least 500 MVA continuous and emergency.	$0	$4,500,000
2014	Upgrade customer-owned WARVUE Substation equipment to achieve a rating of at least 490 MVA continuous and emergency.	$0	$1,500,000
2014	**Cedar Bayou distribution tap - WARVUE 138 kV circuit 84 D** - Reconductor 7.54 miles of existing circuit to achieve a rating of at least 490 MVA continuous and emergency.	$2,800,000	$0
2014	**BAYTOWN - BAYTOWN distribution tap circuit 66 F** - Upgrade to a rating of at least 478 MVA continuous and at least 600 MVA emergency.	$0	$100,000
SUB-TOTAL		**$25,360,000**	**$19,935,000**
TOTAL		**$45,295,000**	

Figure 8 – Mont Belvieu Area with Option 2



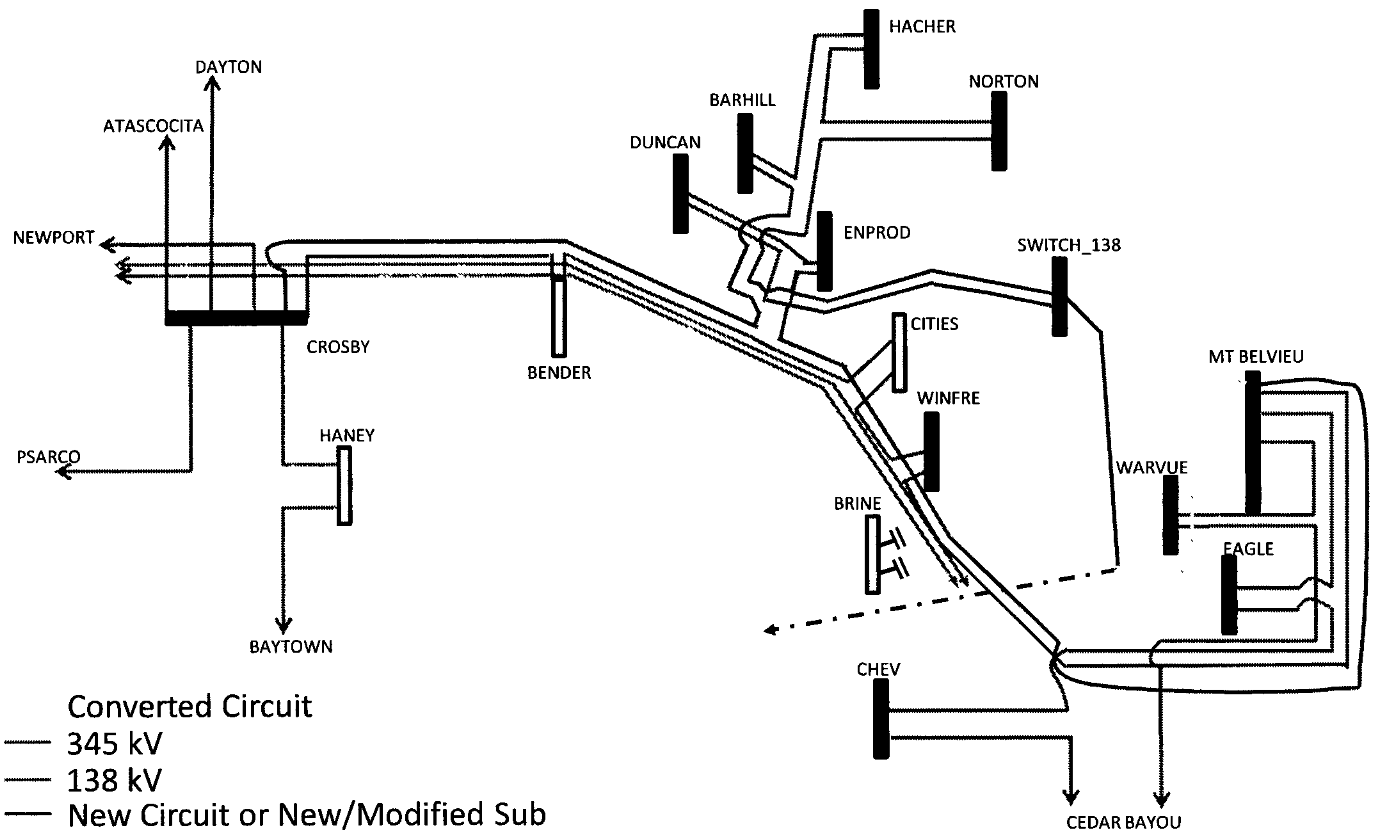
The Mont Belvieu area configuration by 2013 Peak of Option 2 is shown below in Figure 9.

Figure 9: Option 2 – Upgrades by 2013 Peak



The Mont Belvieu area configuration by 2014 Peak of Option 2 is shown below in Figure 10.

Figure 10: Option 2 – Upgrades by 2014 Peak



Converted Circuit
345 kV
138 kV
New Circuit or New/Modified Sub
De-energized Circuit
Breakered Loop Substation
Non-Breakered Loop Substation

CenterPoint Energy anticipates the completion of the new 138 kV switching substation with three 138 kV terminals, the industrial loop circuit reconfiguration, and the 69 kV to 138 kV circuit conversion would be completed prior to the 2014 peak as detailed in Table 4 and illustrated in Figure 10. The total cost to perform these system upgrades is $45,295,000. System analysis shows no line overloading or voltage violations due to single or common mode contingencies if all of the detailed upgrades in Table 4 are implemented. Note that when WINFRE and NORTON eventually come on-line along with the ENPROD upgrade there will temporarily be three additive two-line loop breaker substations beyond the recommended limit prior to the completion of Option 2 in 2014

Rejected Alternatives

CenterPoint Energy studied several potential options that were rejected due to either inability to resolve power flow issues, inability to provide an adequate means of resolving the two-line loop breaker substation issue, or restrictions on the feasibility of construction that precludes it from being a viable option due to cost or timeframe. A list of these rejected alternatives is detailed in Appendix A.

Sensitivity Study

CenterPoint Energy's Transmission Planning department performed a sensitivity study to determine how an increase in Mont Belvieu area load by 15% impacts the transmission system for the two proposed options. The sensitivity study focused on load substations connected to 138 kV Crosby – Mont Belvieu circuit 86 and 138 kV load substations geographically and electrically near 138 kV Mont Belvieu Substation. The PSS/E function SCAL was utilized to increase load by 15% while keeping a constant MW/MVAR ratio.

For Option 1, the impact of the 15% increase in the Mont Belvieu area load was insignificant. No new overloads or voltage violations were observed in 2014 peak or 2016 peak after Option 1 upgrades are scheduled to be completed.

For Option 2, there are significant impacts on the 138 kV transmission system due to the 15% increase in Mont Belvieu area loads. Although there is additional 138 kV support from the second Crosby to Mont Belvieu line, there are single contingencies that lead to radially-fed loads that could potentially cause overloads. See power flow results in Table 6.

Table 5 – Sensitivity Study Default Load Distribution

Substation	2014 Peak (MVA)		2016 Peak (MVA)	
	Base	15% Scale	Base	15% Scale
Crosby	21.11	24.27	21.41	24.63
BENDER	4.50	5.18	4.50	5.18
DUNCAN	31.58	36.32	31.58	36.32
BARHIL	20.89	24.02	20.89	24.02
HACHER	44.34	51.00	44.34	51.00
ENPROD	24.01	27.62	24.01	27.62
CITIES	12.61	14.50	12.61	14.50
BRINE_	0	0	0	0
Mont Belvieu	66.39	76.35	68.89	79.22
EAGLE_	43.74	50.30	43.74	50.30
WARVUE	39.69	45.65	39.69	45.65
CHEVON	106.68	122.68	106.68	122.68
NORTON	53.30	61.29	97.90	112.58
WINFRE	65.00	74.75	65.00	74.75

Table 6 – Option 2 Sensitivity Study 2016 Power Flow Results

CKT	Overloaded Line	Contingency	Opt1_15%Inc _2016PK	Opt2_15%Inc _2016PK
84	CEDARP__138C - CEDAR84_8050	CEDARP__138C - CHEV___138X CKT 86	< 100%	101.6% (526 MVA)
84	CEDAR84__8050 - WARVUE__138A	CEDARP__138C - CHEV___138X CKT 86	< 100%	101.3% (490 MVA)
84	MT_BEL__138A - WARVUE__138A	CEDARP__138C - CHEV___138X CKT 86	< 100%	102.8% (440 MVA)
86	CHEV___138X - EAGLE___138A	CEDARP__138C - WARVUE__138A CKT 84	< 100%	103.4% (360 MVA)

Circuits 84 Cedar Bayou – Cedar Bayou Distribution Tap and Cedar Bayou – WARVUE are scheduled for upgrades as part of the implementation of Option 2 and could potentially be optimized at the time of the initial upgrade to encompass a higher rating to meet the sensitivity loading, but at a higher cost. New upgrades are necessary to meet the loading demands of the sensitivity study for Mont Belvieu – WARVUE CKT 84 and CHEVON – EAGLE_ CKT 86.

Analysis

Option 1 and Option 2 solve Mont Belvieu area reliability concerns. The costs are comparable with Option 1 at a total cost of $42,075,000 and Option 2 at a higher total cost of $45,295,000.

Option 1 provides the most robust solution for many reasons. Besides having a lower overall cost, the leading option does not require as many line upgrades to be performed as Option 2. Numerous outages must be scheduled in order to coordinate the multitude of substation upgrades, thermal uprates, and line reconductors described in Option 2. For Option 2, many industrial customers will have to perform upgrades to existing substation equipment that could lead to delays in the timeline of the project due to coordinating upgrade efforts with CenterPoint Energy. From the 15% load increase sensitivity study, it was concluded that Option 1 requires no additional upgrades due to such an increase in load, but Option 2 would require additional upgrades. This leads to the conclusion that Option 1 is the better long-term solution for the area, although both options alleviate the operational concerns in the area.

Conclusion

CenterPoint Energy recommends ERCOT approve Option 1 at an estimated cost of $42,075,000 to alleviate Mont Belvieu area overloads and voltage violations that are due to an increase in industrial customer load. Option 1 allows for the most robust solution for present and future years without relying on a multitude of substation and line upgrades that could impact the overall project timeline and industrial customer service reliability. Option 1 is expected to be completed before the peak of 2014. This includes consideration of the lead times necessary to implement the proposed project, such as ERCOT review and approval, and material and construction lead times. Overall schedule assumptions for Option 1 include the following:

- Review and approval by ERCOT in first quarter 2012
- Material acquisition, ROW acquisition, and construction complete by peak of 2014

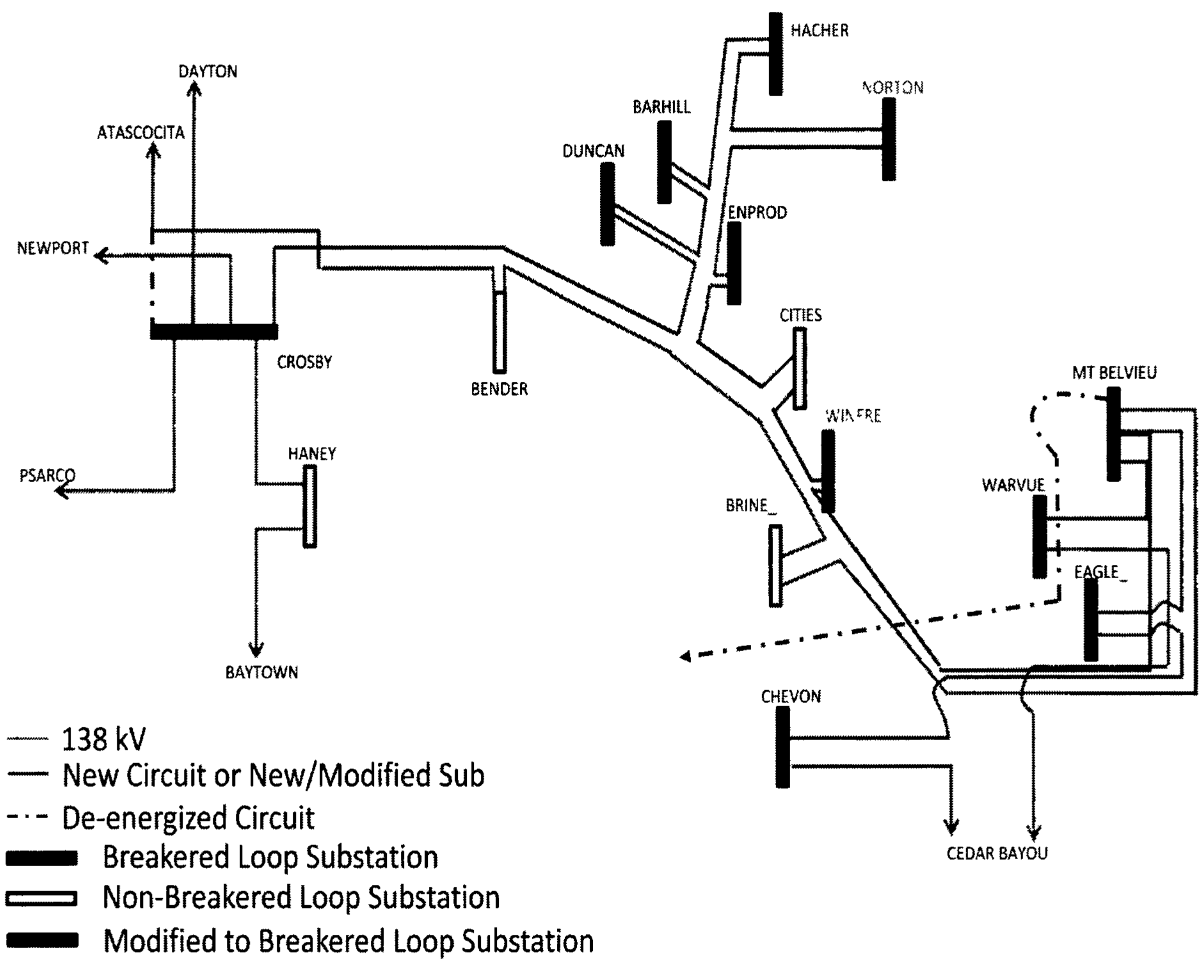
This schedule could be delayed should ERCOT require additional review time to approve this project or if ROW acquisition is delayed.

Appendix A – Rejected Alternatives

- Rejected Alternatives that Failed to Adequately Resolve Power Flow
    - *Atascocita –Mont Belvieu Circuit*

CenterPoint Energy studied a scenario that involved removing the Crosby to Atascocita circuit connection and extending the Atascocita circuit to the Mont Belvieu Substation in open circuit position. The additional 138 kV circuit from Crosby to Mont Belvieu alleviates overloads and low voltage violations; however, it did not solve all of them. This alternative was rejected due to the inability to resolve the overloads and voltage violations due to single and common mode contingencies. This alternative also does not resolve the two-line loop breaker substation issue for the addition of NORTON, ENPROD, and WINFRE Substations.

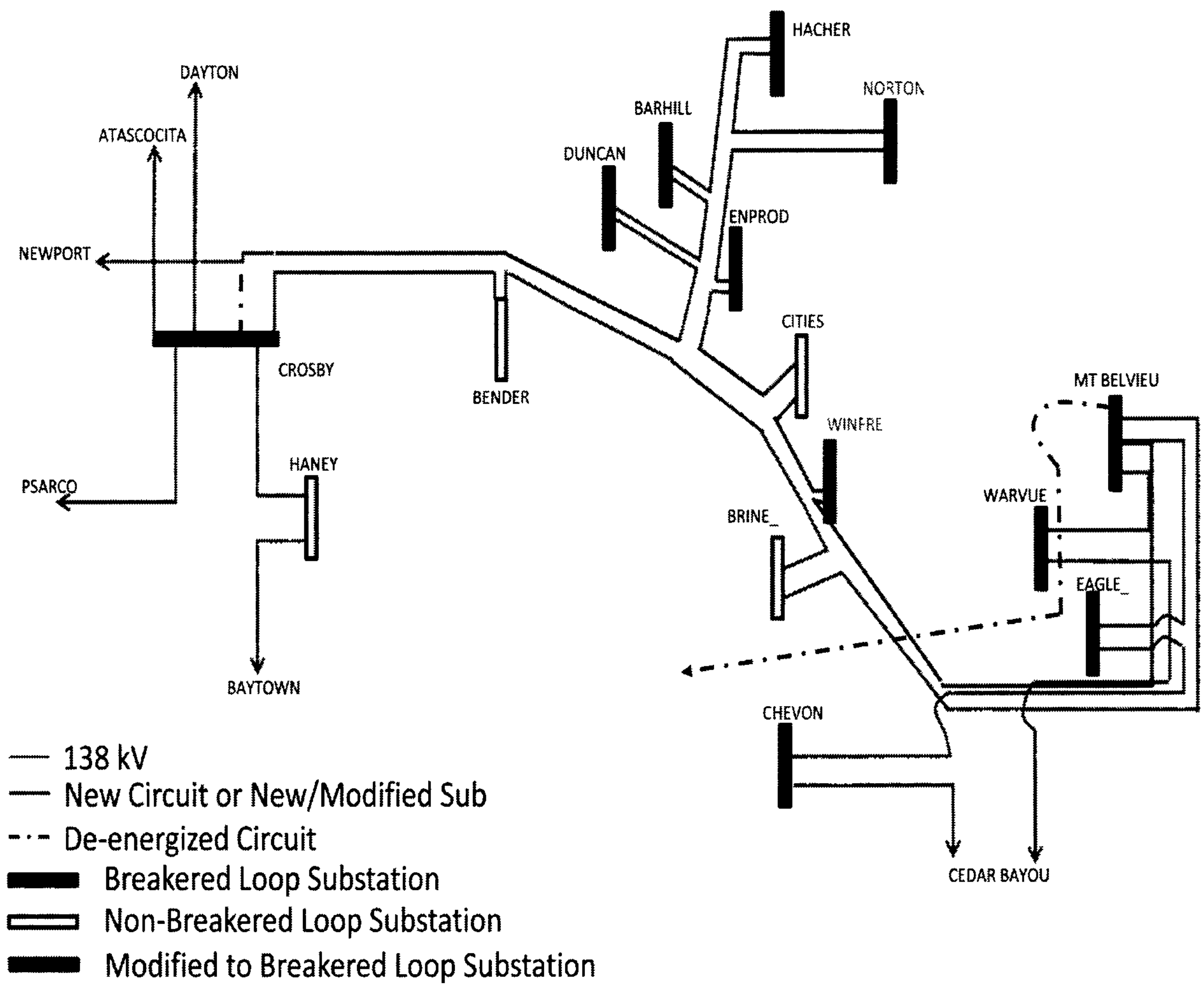
Figure 11: Rejected Alternative – Atascocita to Mont Belvieu



- *Newport – Mont Belvieu Circuit*

CenterPoint Energy studied a scenario that involved removing the Crosby to Newport circuit connection and extending the Newport circuit to the Mont Belvieu Substation in an open circuit position. The additional 138 kV circuit from Crosby to Mont Belvieu alleviates overloads and low voltage violations; however, it did not solve all of them. This alternative was rejected due to the inability to resolve the overloads and voltage violations due to single and common mode contingencies. This alternative also does not resolve the two-line loop breaker substation issue for the addition of NORTON, ENPROD, and WINFRE Substations.

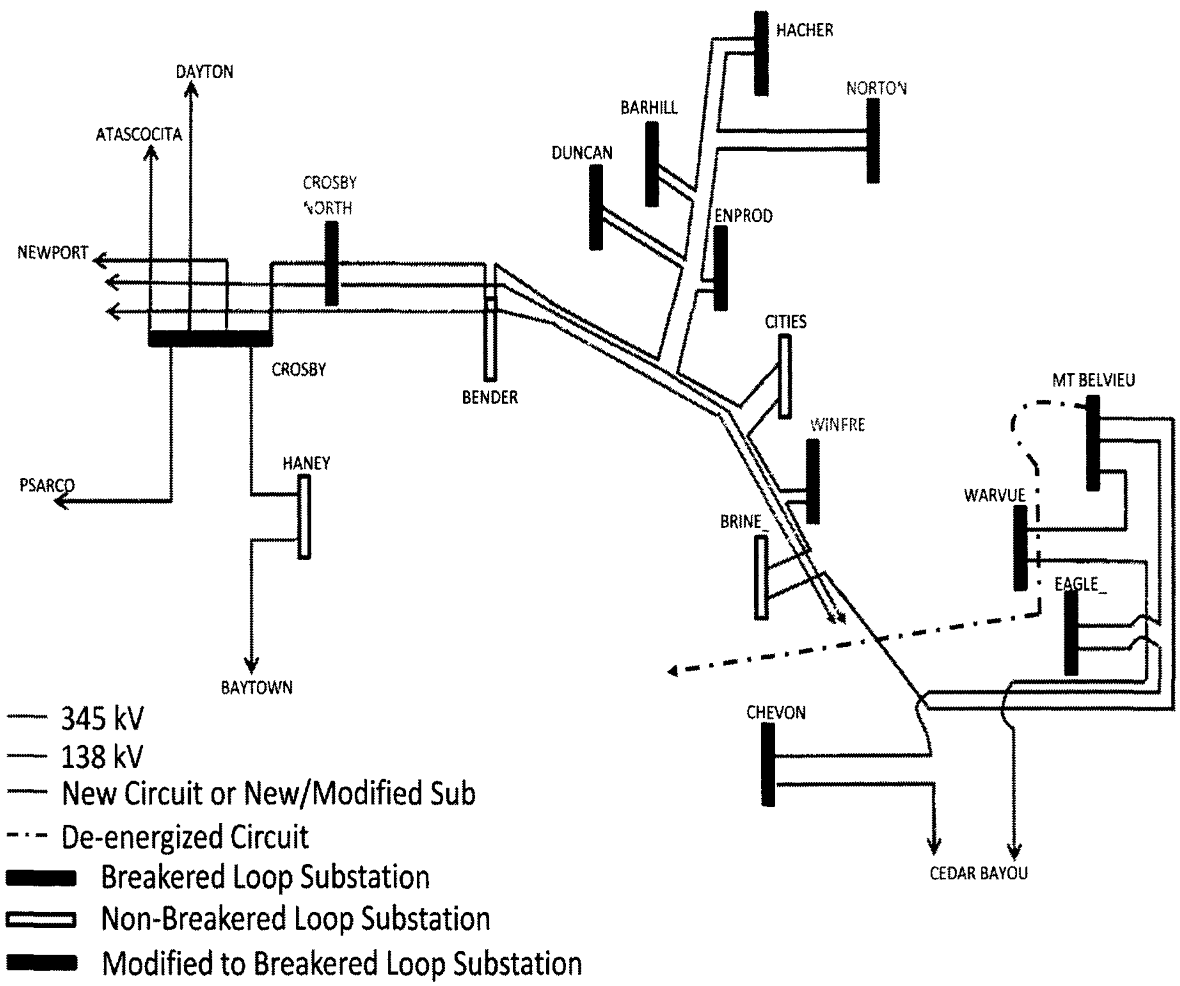
Figure 12: Rejected Alternative – Newport to Mont Belvieu



- *Crosby North Substation*

CenterPoint Energy studied the scenario of building a 345/138 kV substation north of the Crosby Substation in the existing right–of–way. The substation would include a 345/138 kV 800 MVA autotransformer to provide support on the existing 138 kV circuit 86 between Crosby and Mont Belvieu. Power flow results showed that significant line upgrades would be needed for the common tower contingency removing Cedar Bayou support to Mont Belvieu. This alternative was rejected due to the inability to resolve the overloads and voltage violations due to single and common mode contingencies. This alternative also does not resolve the two-line loop breaker substation issue for the addition of NORTON, ENPROD, and WINFRE Substations.

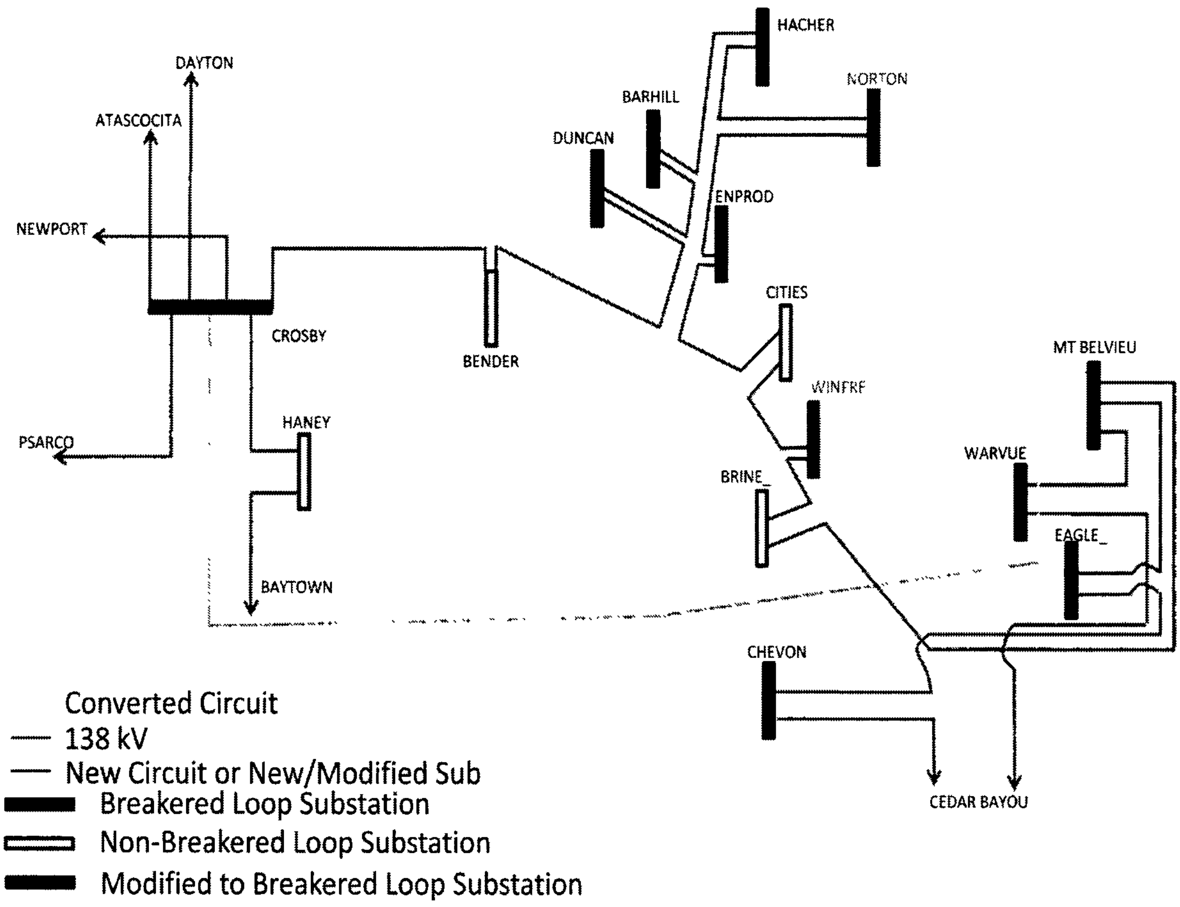
Figure 13: Rejected Alternative – Crosby North



- Rejected Alternative that Resolved Power Flow but Failed to Resolve Two-Line Loop Breaker Substation Issue
    - *Re-build 69 kV circuit Crosby – Mont Belvieu*

CenterPoint Energy studied a scenario that involved rebuilding a 69 kV circuit between Crosby and Mont Belvieu to a 138 kV single circuit. The additional 138 kV circuit to Mont Belvieu alleviates overloads and low voltage violations. However, the solution was rejected because it does not resolve the number of two-line loop breaker substations on circuit 86 from the addition of NORTON, ENPROD, and WINFRE Substations.

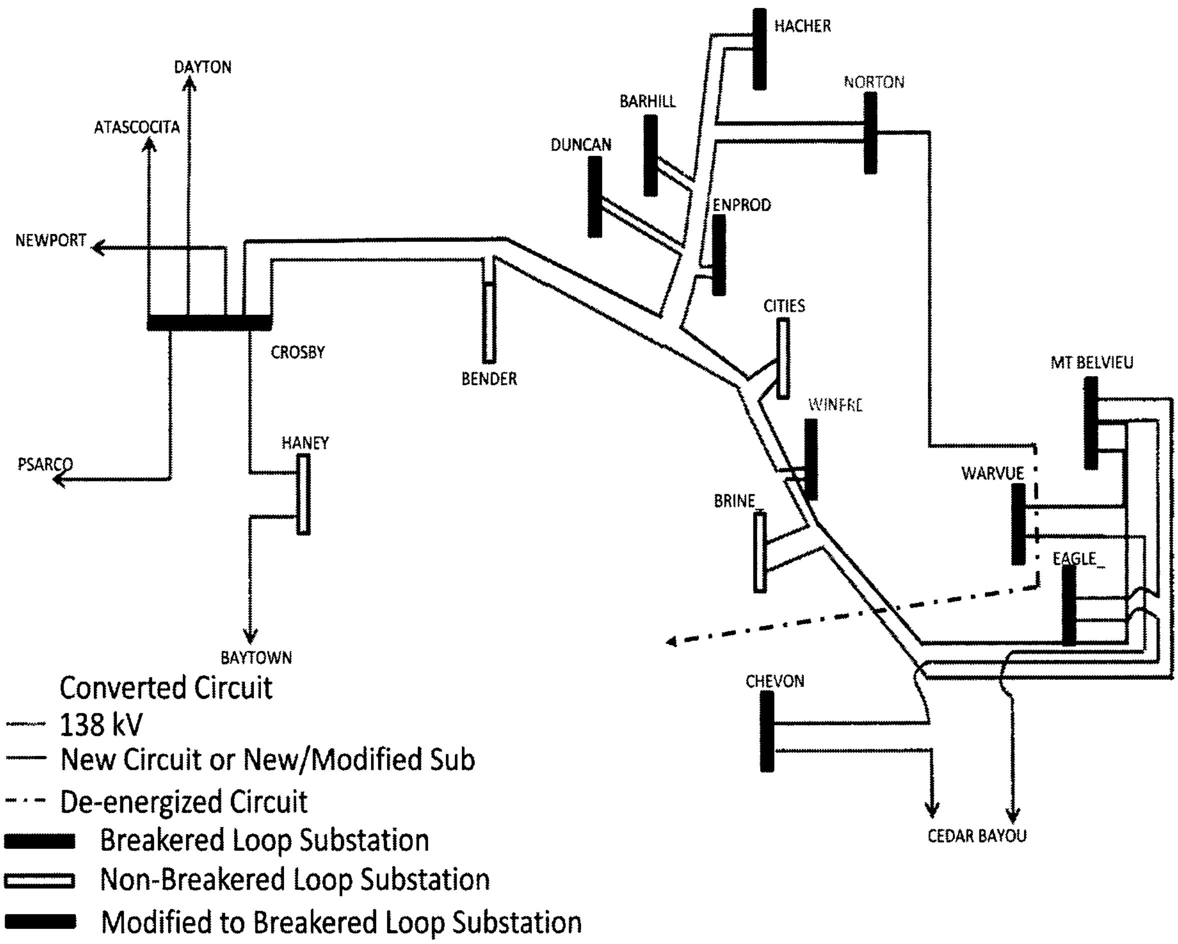
Figure 14: Rejected Alternative – 69 kV Circuit Re-build



- Rejected Alternatives Due to Restrictions on Feasibility of Construction
    - *NORTON Customer Expansion*

CenterPoint Energy studied a scenario that included expanding the new customer-owned NORTON Substation to three 138 kV line positions and adding a second circuit from Crosby to Mont Belvieu. The new three-position NORTON Substation would act as a major breakered substation between both Crosby and Mont Belvieu to mitigate the impact of adding additional two-line loop breaker substations on circuit 86. The additional circuit between Crosby and Mont Belvieu would alleviate overloading and low voltage violations. This alternative was rejected due to the physical restrictions of building a new circuit in new right-of-way from NORTON Substation to Mont Belvieu Substation.

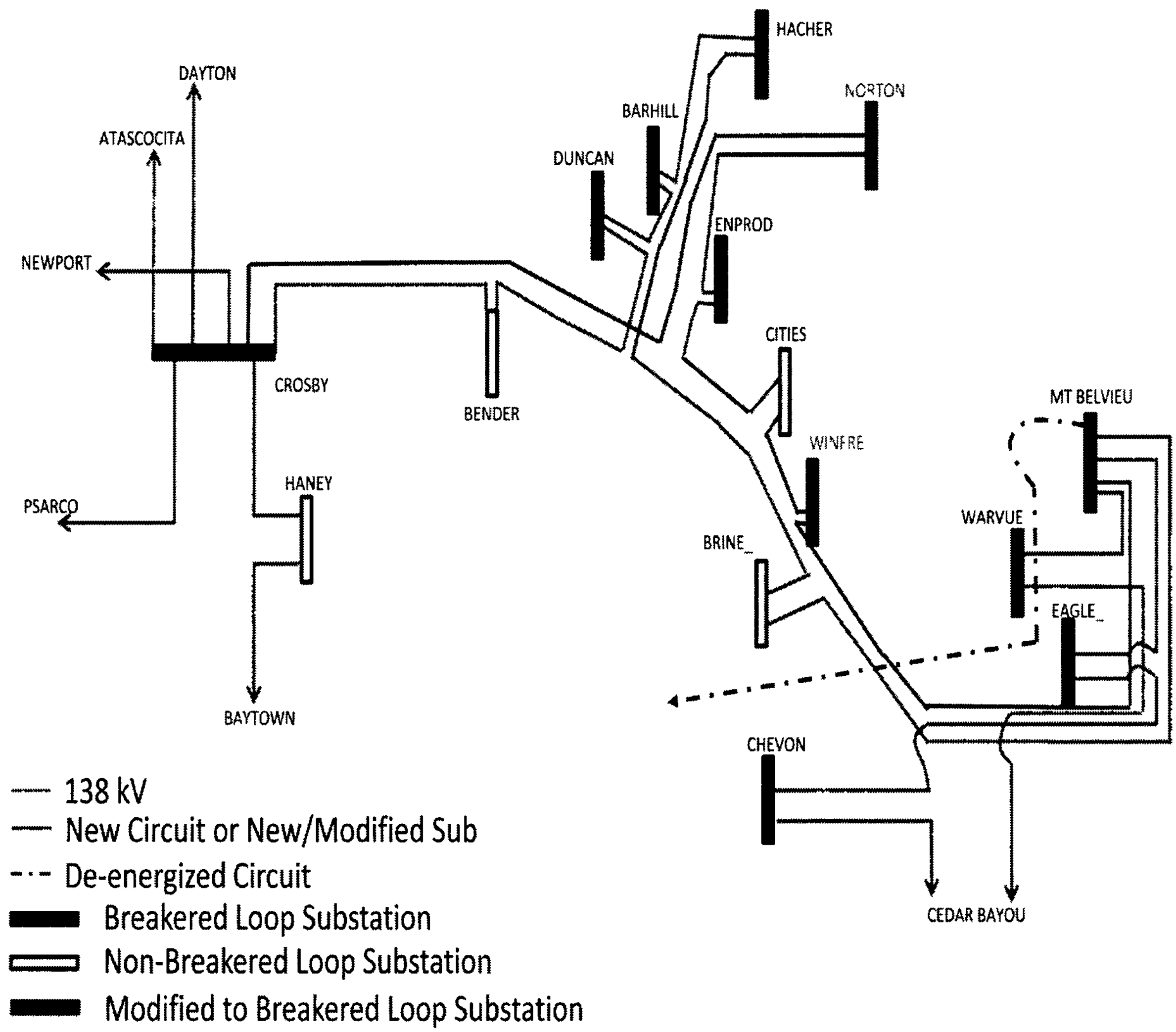
Figure 15: Rejected Alternative – NORTON Expansion



- *Expand Industrial Loop to Four Circuits*

CenterPoint Energy studied the scenario of utilizing a second circuit from Crosby to Mont Belvieu and expanding the industrial customer loop to four circuits. The second circuit would alleviate line overloads and low voltage violations, while the expansion of the industrial customer loop would allow CenterPoint Energy to separate two-line loop breaker substations onto different circuits between Crosby and Mont Belvieu Substations. This alternative was rejected due to physical restrictions in expanding the existing right–of–way serving the industrial loop north of DUNCAN Substation.

Figure 16: Rejected Alternative – Expand Industrial Loop



CenterPoint™ Energy

2012 Northwest Houston Reliability Project

February 27, 2009

1. Executive Summary

Improvements are needed to maintain the reliability of CenterPoint Energy's service in the northwest Houston area. Several N-1 events are shown to cause transmission element overloads in the area beginning in 2011 and rapidly increasing by 2013 under the modeled operating conditions; the worst of which is the overloading of the T.H. Wharton (THW) 800 MVA 345/138 kV Autotransformer #1. Even more of a concern are the many voltage violations seen in the area for N-1 events, some well below CenterPoint Energy's design criteria of 0.95p.u. Additionally, many common mode contingency events result in numerous transmission element overloads above their emergency ratings and voltage violations below 0.92p.u. For example, the THW Autotransformer #1 overloads up to 40% above its 914 MVA emergency rating by 2013 and many of the 138 kV bus voltages in the area are below 0.9p.u.

To eliminate these major system reliability concerns and meet CenterPoint Energy Transmission System Design Criteria and the Electric Reliability Council of Texas (ERCOT) Planning Criteria, CenterPoint Energy studied several options and recommends the following set of projects to eliminate the problems in the northwest Houston part of CenterPoint Energy's transmission system:

1. Expand the Zenith substation to add one 800 MVA 345/138 kV autotransformer;
2. Build two 5 mile long 138 kV lines from the Zenith substation to the east on a common tower connecting with existing circuits near the Gertie substation;
3. Reconfigure ckt.76 Addicks to Kluge and ckt.21 Camron to Kluge to form a Zenith to Gertie tap to Satsuma tap to Addicks circuit, a Zenith to Gertie tap to Cyfair tap to Kluge circuit, and a Camron to Cyfair to Kluge circuit;
4. Upgrade the newly formed Gertie tap to Satsuma tap circuit segment and Gertie tap to Cyfair tap to Kluge circuit segments;
5. Upgrade the Addicks 138 kV substation to an 80 kA fault duty rating.

These projects are recommended as the most cost-effective solution to the reliability concerns identified in the northwest Houston area and are expected to cost an estimated $26.64 million. Additionally, the proposed option eliminates one common tower outage from causing the loss of approximately 400 MW of load. The proposed option also places an autotransformer at a new location on the CenterPoint Energy system, which avoids increasing the number of autotransformers at an existing site. The Zenith site is an excellent location for further expansion to the south to the growing Katy, Texas area, which could significantly strengthen the system and address concerns expected to be seen in future years. CenterPoint Energy estimates completing all of the listed projects by summer peak 2012, which takes into consideration the typical lead times necessary to implement the proposed projects, including ERCOT review and approval, regulatory review and approval, and materials and construction lead times. The project could be completed sooner (in 2011) should ERCOT designate this project as "critical to reliability", which would shorten the project calendar by six months by shortening the Certificate of Convenience and Necessity (CCN) approval deadline from 1 year to 6 months. This project meets the criteria in the ERCOT Planning Charter for regional review and is therefore submitted to the ERCOT Regional Planning Group for review and comment.

2. Background

The Northwest Houston area (see Figure 1) is experiencing increased loading of its existing 345/138kV autotransformers and a relatively small number of 138kV transmission lines that is leading to low voltage problems and concern for large block contingency load loss within CenterPoint Energy's service area. Power flow models of future years indicate that violations of CenterPoint Energy Transmission Design Criteria and ERCOT Transmission Planning Criteria will occur in the northwest Houston area with rapidly increasing severity. This study report proposes transmission system improvements to remedy the thermal loading and voltage design criteria violations within the northwestern Houston area.

3. Study Assumptions

CenterPoint Energy used the ERCOT Steady-State Working Group (SSWG) Data Set B summer peak cases published in December 2007 as a starting point for the study. These cases include the following Houston Area Constraints Mitigation Phase II (HACM II) projects, approved by ERCOT Board of Directors (Board) in August of 2007:

1. Build a new 345kV Singleton substation near the point where the four 345kV tie lines into north Houston intersect near Singleton, Texas in Grimes County, starting from 2009 summer case.
2. Build a new 345kV Zenith substation near the point where the 345kV O'Brien – Singleton and 345kV T.H. Wharton westbound corridors intersect, starting from 2011 summer case.

The following projects approved by the ERCOT Board in May of 2008 were added to the ERCOT cases:

1. Build a new 345/138kV Rothwood substation by looping 345kV ckt.74 Kuykendahl to King into Rothwood 345kV substation and 138kV ckt.66 Rayford tap section into Rothwood 138kV substation. Add one 800MVA 345/138kV autotransformer at Rothwood substation.
2. Convert Rayford 138kV substation into a loop tap connection.
3. Upgrade 138kV ckt.66 Tomball to Rothwood to Rayford to Louetta tap.

CenterPoint Energy anticipates that the completion date of all projects listed above will precede the time frame analyzed in the present study. Also, HACM II and the present study address a different set of concerns. While HACM II reduces congestion into the Houston area, the 2012 Northwest Houston Reliability Project eliminates existing, as well as prevents future, design criteria violations in the northwestern Houston area.

Other modifications to the ERCOT cases include adding tap sections (northwestern CenterPoint Energy area only) and zero sequence data for short circuit studies. See Appendix A for a complete list of changes made to the ERCOT SSWG cases.

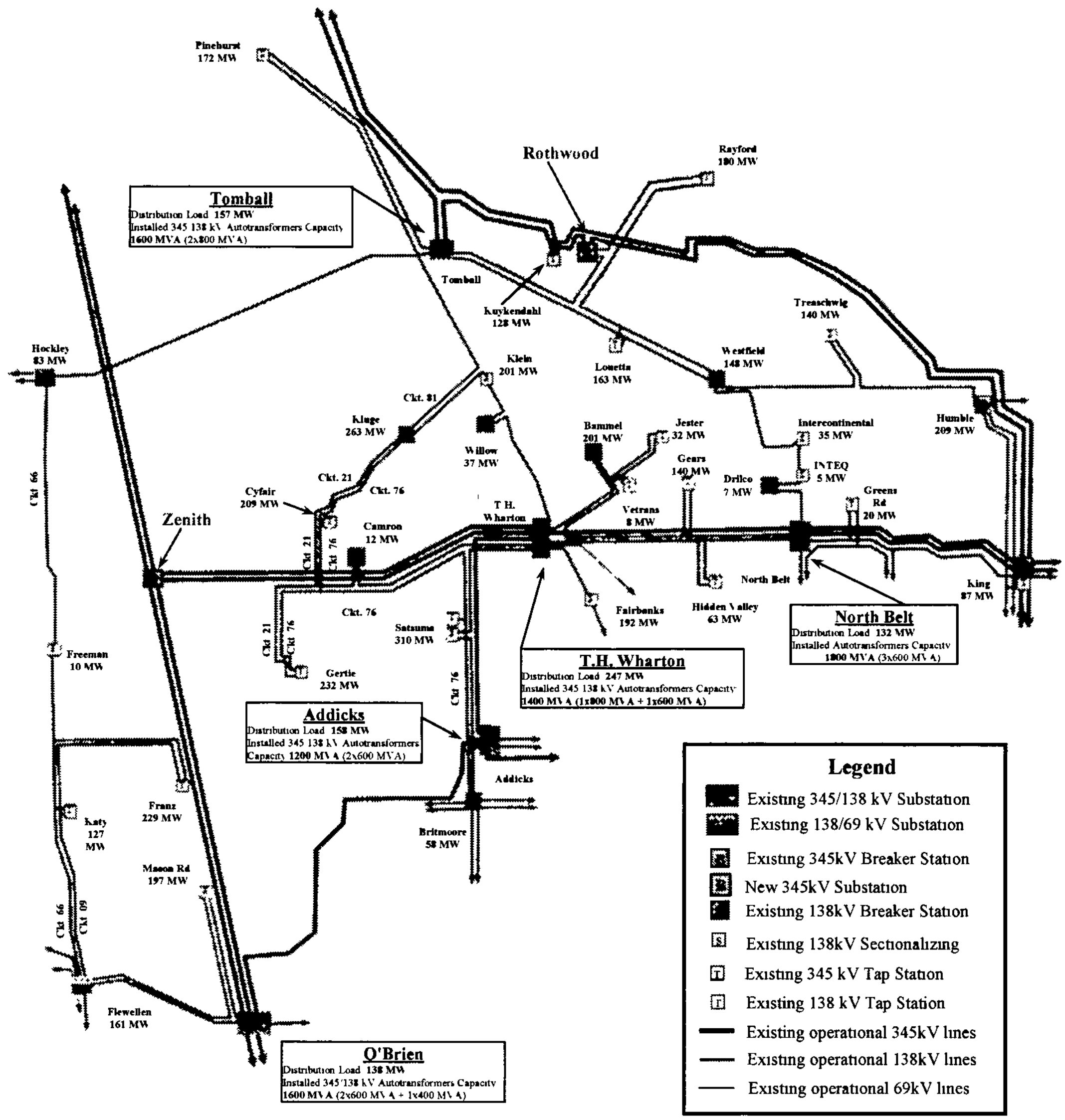


Figure 1: Northwestern Houston Area – 2011 Planned System Configuration

4. Northwestern Houston Area Contingency Analysis

Analysis of the power flow models described previously indicates violations of CenterPoint Energy's design criteria and ERCOT Transmission Planning Criteria in future years in the northwestern Houston area. CenterPoint Energy performed North American Electric Reliability Corporation (NERC) Category B and Category C contingency analysis. The Category B contingency analysis study addresses the failure of a single transmission line or autotransformer, whereas the Category C deals with the outage of two transmission network components (i.e. autotransformers and/or transmission lines) due to the failure of a single tower or a common breaker.

The Category B contingency analysis indicates that the outage of 138kV Circuit 21 from THW (West bus) to Camron would cause the THW 800MVA 345/138kV autotransformer A1 to overload as early as 2011. Similarly, the O'Brien 345/138kV 400MVA autotransformer A3 loading threatens to reach its continuous rating in 2012 when the 345/138kV autotransformer A2 at O'Brien is out of service. In 2012, the outage of the 138kV Circuit 21 from Kluge to Camron will cause a thermal overload on 138kV Circuit 76, the transmission line section between the Cyfair tap and Kluge. Also, this outage would cause THW autotransformer A1 to exceed its thermal limit and the bus voltage at 138kV Gertie and Cyfair distribution substations (the sections tapped on 138kV circuit 76 from Kluge to Addicks) to fall below the 95% specified in CenterPoint Energy's design criteria in 2012.

The complete results of the Category B contingency analysis of thermal overload and of bus voltage criteria violations for the northwestern Houston area are presented in Table 1 and Table 2, respectively.

Table 1: NW Houston Area Single Contingencies Thermal Loading Results.

Overloaded Line	Category B Contingency	kV	Rate A	Summer Peak Base Case		
				2011	2012	2013
Ckt 09 Katy to Franz	Ckt.66 Flewellen to Freeman	138	220	108.3%	112.1%	115.8%
Ckt.76 Cyfair to Kluge	Ckt.21 Camron to Kluge	138	227	< 95%	102.0%	104.4%
Ckt 76 Satsuma to Gertie	Ckt.21 Camron to Kluge	138	455	< 95%	99.3%	106.7%
A1 @ TH Wharton	Ckt.21 Camron to TH Wharton	345/ 138	800	107.6%	117.3%	125.1%
A3 @O'Brien	A2 @O'Brien	345/ 138	400	95.4%	98.3%	99.2%

Table 2: NW Houston Area Low Voltage Results During Single Contingencies

Buses		Category B Contingency	kV	Summer Peak Base Case		
				2011	2012	2013
45700	Camron	Ckt.21 TH Wharton to Camron	138	>0.95	0 9491	0.9406
45711	Cyfair (tap on Ckt.21)		138	>0.95	>0.95	0 9419
45801	Gertie (tap on Ckt.21)		138	>0.95	0 9494	0.9409
45712	Cyfair (tap on Ckt.76)	Ckt.21 Camron to Kluge	138	>0.95	0.9433	0.9343
45802	Gertie (tap on Ckt 76)		138	>0.95	0.9459	0.9374
46240	Pinehurst	Ckt.81 Pinehurst to Tomball	138	0.9478	0.9267	0.915
45971	Kuykendahl (tap on Ckt.74)	Ckt.74 King to Rothwood	345	0.9651	0 9451	0 9451
46290	Rothwood		345	0.9652	0 9459	0 9458
46500	Tomball		345	0.9654	0.9436	0.9437
45940	Klein	Ckt.81 TH Wharton to Willow	138	>0.95	0.9276	0.9178
45952	Kluge		138	>0.95	0.9417	0.9327
46660	Willow		138	0.95	0.9269	0.917

The Category C contingency analysis indicates that the double outage of 138kV circuits 21 from THW (West) to Camron and 76 from Addicks to Kluge, which shares the same towers for an approximate length of 5 miles, will cause the 800MVA autotransformer #1 at THW to load to 120% over its emergency rating (Rate B) in 2011 increasing to 140% by 2013. The same double contingency will cause a thermal overload on 138kV circuit 81: line section between THW (East) and Willow of 109% over its 717 MVA emergency rating in 2011 increasing to 154% by 2013, whereas the line section between Willow and Klein starts to overload in 2012. In addition to the thermal overloads, this double contingency would cause the 138kV voltages at Camron, Gertie and Cyfair substations to fall well below 92 percent as early as summer of 2011.

An additional Category C contingency, the failure of a 138kV breaker to operate at the Kluge 138 kV substation, will de-energize 138kV ckt.21 from Kluge to Camron and ckt.81 from Kluge to Klein. This double outage will cause 138kV ckt.76 from Addicks to Kluge to exceed its emergency thermal rating of 580 MVA by 2012 for the line section between Satsuma Tap and Gertie Tap, an approximate length of 10 miles. Also, the same double outage will cause bus voltage design criteria violations at 138kV Gertie, Cyfair and Kluge substations well below 92%. Many of the common mode voltage violations are below CenterPoint Energy's under voltage load shedding (UVLS) setpoint of 0.91pu, meaning that the outages during the operating conditions would likely result in shedding load at these buses.

The complete results of the Category C contingency analysis of thermal overload and bus voltage criteria violations for NW Houston area are presented in Table 3 and Table 4, respectively.

Table 3: NW Houston Area Common Mode Contingencies Thermal Loading Results.

Overloaded Line	Category C Contingency	kV	Rate B	Summer Peak Base Case		
				2011	2012	2013
Ckt.76 Addicks to Satsuma Tap	Ckt 21 Kluge to Camron & Ckt.81 Kluge to Klein	138	789	< 95%	102%	110%
Ckt 76 Satsuma Tap to Gertie Tap			580	< 95%	115%	125%
Ckt.81 TH Wharton to Fairbanks	Ckt 21 Camron to TH Wharton & Ckt.24 TH Wharton to Satsuma		441	103%	104%	104%
Ckt 81 TH Wharton to Willow	Ckt 21 Camron to TH Wharton & Ckt 76 Addicks to Kluge		717	109%	137%	154%
Ckt.81 Klein to Willow			789	< 95%	119%	134%
Ckt.81 Kluge to Pinehurst			455	< 95%	103%	114%
Autotransformer A1 @TH Wharton	Ckt.21 Kluge to Camron & Ckt 81 Kluge to Pinehurst	345/138	914	103%	115%	117%
	Ckt.21 Camron to TH Wharton & Ckt 76 Addicks to Kluge			120%	134%	140%
Autotransformer A2 @N. Belt	A3 @N. Belt & A1@N. Belt		672	99.8%	103%	105%

Table 4: NW Houston Area Low Voltage Results During Common Mode Contingencies

Buses		Category C Contingency	kV	Summer Peak Base Case		
				2011	2012	2013
44261	Franz (tap on Ckt.09)	Ckt.73 Flewellen to Obrien & Ckt.66 Flewellen to Freeman	138	0.9274	0.9186	0.9093
45712	Cyfair (tap on Ckt.76)	Ckt.21 Kluge to Camron & Ckt.81 Kluge to Klein	138	0.9094	0.8701	0.8533
45802	Gertie (tap on Ckt.76)		138	0.9175	0 8803	0.8647
45952	Kluge	Ckt.21 Kluge to Camron & Ckt.81 Kluge to Klein	138	0.9087	0.8729	0.8557
		Ckt 21 Camron to TH Wharton & Ckt76 Addicks to Kluge		0.925	0.8473	0.7939
45700	Camron	Ckt 21 Camron to TH Wharton & Ckt 76 Addicks to Kluge	138	0.8912	0.7925	0.7284
45711	Cyfair (tap on Ckt.21)		138	0.8973	0.8019	0.7393
45801	Gertie (tap on Ckt.21)		138	0.8915	0.7929	0.7288
45940	Klein		138	> 0 93	0.8851	0.8403
46660	Willow		138	> 0.93	0.9179	0.8798

These violations of CenterPoint Energy Transmission System Design Criteria indicate that transmission improvements are needed to maintain the reliability of CenterPoint Energy's service in the northwestern region.

5. Leading Options

The contingency analysis reveals the need for at least one new 345/138kV autotransformer as a means to alleviate the loading of the existing 345/138kV autotransformers within the northwestern Houston area. CenterPoint Energy considered locations for an autotransformer that would not only eliminate the autotransformers' overloading conditions, but would also increase the reliability and provide for growth within the northwest Houston region. The most promising locations are where the 345kV circuits and the 138kV circuits are in close enough proximity to each other to minimize cost and landowner impact. Also, the location must involve circuits in reasonable proximity to THW, North Belt, and O'Brien substations, so that the option would be effective in relieving the loading on the autotransformers installed at these substations. Furthermore, when installing new 345/138 kV autotransformers, CenterPoint Energy seeks to limit the number of autotransformers installed at a given substation site for the following reasons:

- Reliability – Reduce the 345/138kV autotransformers' capacity lost due to a Category D contingency. Category D contingencies are extreme events, including loss of a substation (one voltage level plus transformers);
- Geographical diversity – Installing 345/138kV autotransformers at multiple key locations within CenterPoint Energy's service area provides flexibility in adapting to future generation additions and load growth.

CenterPoint Energy evaluated eleven possible locations for a new 345/138kV autotransformer in the initial screening studies with the focus on alleviating the THW, O'Brien, and North Belt autotransformer loading problems. A secondary focus was to improve the line loading and low voltage problems within the northwestern Houston area resulting from Category B and C contingencies. A new 345/138kV 800MVA autotransformer was added to the study cases at each of the following locations: new Hardin substation (where the 345kV double circuit line is in close proximity to the 138kV double circuit that loops up to the Pinehurst substation), Tomball, Humble, King, North Belt, Addicks, O'Brien, THW, Zenith, New Site 1 (point in THW to Zenith corridor at which ckt.21 and ckt.76 turn north towards Cyfair substation), and New Site 2 (point in THW to Zenith corridor at which the two 138 kV circuits turn south towards Satsuma near Jones Road). The Category B contingency analysis results indicate that the Humble, King, North Belt, Tomball, Addicks, O'Brien, and Hardin options have limited or no impact on solving the northwestern Houston area 345/138kV autotransformers' loading problems at all three locations (THW, O'Brien and North Belt). Additional screening studies revealed promising results for New Site 1 (Option 3). However, New Site 2 did not work as well. As has been discussed, one of the worst common mode contingencies is the loss of ckt.21 THW to Camron and ckt.76 Addicks to Kluge, which is essentially loss of the 138 kV double circuit line west of New Site 2. New Site 2 does not eliminate the problems caused by the loss of the 138 kV double circuit line west of New Site 2. The 345kV injection point needs to be at or west of New Site 1, so that a strong source can feed Gertie, Cyfair, and Kluge loads if the 138 kV double circuit line to THW is out. For this reason, New Site 1 will be considered in this study while New Site 2 will not be pursued further. From the initial screening studies, the locations showing positive results were reduced to three likely locations, THW, Zenith, and New Site 1.

CenterPoint Energy evaluated a series of options to address the predicted design criteria violations presented in the previous tables. The three leading options are described here in more detail.

Option 1 – Install a new 345/138kV 800MVA autotransformer at THW in parallel with existing 800MVA Auto #1 (see Figure 2). Convert Klein substation to a breaker substation and build a new 138kV circuit from THW to Klein on the open position of existing towers between the two locations. In addition, install 138kV 80MVAR capacitor bank at Klein which represents the largest cap bank that can be placed at Klein and still meet CenterPoint Energy's criteria of limiting voltage rise due to cap bank switching to 2%.

Option 2 – Expand 345kV Zenith to 345/138kV substation and install a new 345/138kV 800MVA autotransformer. Build a new 138kV double circuit from the new 138kV Zenith substation to Gertie Row and connect to existing 138kV double circuits to Gertie. Reconfigure the existing 138kV ckt.76 from Kluge to Addicks and ckt.21 from Kluge to Camron to create three new 138kV circuits: ckt.2 from Zenith to Kluge, ckt.1 from Zenith to Addicks and ckt.21 from Kluge to Camron (see Figure 3). This option is expected to require a CCN because it would entail the