



## **Transmission Strategy and Planning**

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Final Report  
Green River 750 MW Project  
LGE-LGI-2007-001

Facilities Study Report  
July 30, 2008  
Revised August 11, 2008

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## Introduction

The Independent Transmission Organization (ITO) received a request for generation interconnection from the [REDACTED] in March 2007. [REDACTED] requested the addition of a 750 MW unit (Project) near the existing Green River generating facility north of Central City, KY. [REDACTED] requested Network Integration Resource Service from the Project to the Kentucky Utilities Company (KU) and Louisville Gas and Electric (LG&E) Network Loads. The proposed commercial operation date for the Project was June 1, 2014. The ITO completed a System Impact Study on December 17, 2007. An Interconnection Facility Study Agreement (FSA) was executed on February 1, 2008. The proposed commercial operation date for the Project has been revised to January 12, 2015 in the FSA. The ITO delegated the Facilities Study to the TO (E.ON Transmission).

## Power Flow Model and Analysis

E.ON Transmission's Facility Study used the 2016 summer power flow models developed by the ITO for the System Impact Study. E.ON evaluated the following four 2016 summer scenarios: 1) without Thoroughbred without Green River, 2) without Thoroughbred with Green River, 3) with Thoroughbred without Green River and 4) with Thoroughbred with Green River. The ITO cases were reviewed and modified as follows:

### All Scenarios –

#### TSR 2006-014 Lexington NW

The customer has changed the location of the tap from the 69 kV to the 138 kV. The load at 11LEXNW 69 was moved to 11HAEFLN 138.

#### TSR 2006-015 Higby Mill 69

The customer has changed the location of the tap from the 69 kV to the 138 kV. The load at 11high2 69 was moved to 11HIGBY 138.

The model was changed accordingly.

#### TSR 2006-016 Lexington East

The customer has canceled the new station and will be adding capacity at Bryant Road. The load at 11LEX E 69 was moved to 11BRYANR 69.

Scenario 2 – This case is comparable to the ITO S1 scenario. That scenario included the construction of a Green River (E.ON) to Paradise (TVA) 161 kV line and the addition of a fourth 161-138 kV, 120 MVA transformer at Green River. The impedance of the Green River to Paradise 161 kV line was revised to be consistent with the estimated length of 13.3 miles:

SIS Impedance	R=0.00230	X=0.02210	BC=0.02300
FS Impedance	R=0.00283	X=0.02692	BC=0.02808

The installation of a fourth 161-138 kV transformer would require reconfiguration of the 138 kV station, an additional bay in the 161 kV station, breaker additions at both voltages and construction of a 161 kV line between the two stations with numerous line crossings. Replacing the three existing 120 MVA transformers with 150 MVA transformers will provide sufficient transformer capacity. The model was revised to include three 150 MVA transformers.

Scenario 4 – This case is comparable to the ITO S12 scenario. That scenario included the replacement of the three existing 120 MVA transformers with 150 MVA transformers and the addition of a fourth 161-138 kV, 150 MVA transformer at Green River. The installation of a fourth 161-138 kV transformer would require reconfiguration of the 138 kV station, an additional bay in the 161 kV station, breaker additions at both voltages and construction of a 161 kV line between the two stations with numerous line crossings. Replacing the three existing 120 MVA transformers with 200 MVA transformers will provide sufficient transformer capacity. The model was revised to include three 200 MVA transformers.

A contingency analysis was performed simulating the transmission contingencies in Appendix A and the generation contingencies in Appendix B. The worst case flows on impacted facilities that exceed the facility rating are summarized Appendix C.

### Short Circuit Model and Analysis

The ITO developed a BREC, E.ON, TVA short circuit model for this study from the three separate Company models because there was not a comprehensive model available at the time of the ITO SIS that included the three Companies. The SERC SCDWG developed a short circuit model of 2008 summer during the spring of 2008 that includes representation of BREC, E.ON, TVA. E.ON's current short circuit model was developed by replacing the EON equivalent in the SERC 2008 summer model with a detailed model of EON. The current E.ON model was used in the Facility Study analysis.

The breaker replacements identified in the SIS report were based on a simplified calculation: (base case breaker duty\* (post-case bus fault level/base-case bus fault level)). The breaker replacements identified in the Facility Study Report are based on a simulation of the branch faults. The breakers that must be replaced because of short circuit requirements are shown in the following table:

**Required Breaker Replacements**

Station	kV	ID	S2	S4
Green River	161	864	X	
Green River	161	868	X	
Green River	161	872	X	
Green River	161	878	X	X
Green River	161	884	X	X
Green River	161	888	X	
Green River	138	708	X	X
Green River	138	724	X	
Green River	138	744	X	
Green River	138	768	X	X
Green River	138	778	X	X
Green River	69	610	X	
Green River	69	628	X	
Green River	69	634	X	

### Stability Model and Analysis

The Department of Electrical & Computer Engineering at the University of Kentucky performed a stability analysis to verify the results of the SIS and to assess the stability impact of the configuration of the 161 kV line terminations at Green River. The assessment simulated a sustained three phase fault on one branch and the subsequent tripping of the faulted branch and one of the other branches. For example, the worst combination for Scenario 2, is a fault on the Green River – Wilson 161 kV line and the subsequent tripping of the Green River – Paradise 161 kV line. Therefore, these two lines should not be connected to a common breaker that would result in tripping both lines during a breaker failure. The proposed configurations in Appendix D have the following critical clearing times (cycles):

Fault Type	Scenario 2	Scenario 4
Single Line Ground (SLG)	15+	15+
Three Phase (5cyc) – SLG	15+	14
Three Phase	9-11	7

All of the 161 kV breakers at Green River will be designed for independent pole operation to reduce the likelihood of a sustained three phase fault. All six of the existing 161 kV breakers must be replaced because of short circuit requirements in Scenario 2; therefore, no additional breaker replacements are required. Four additional breaker replacements are required for Scenario 4 since only two of the six existing 161 kV breakers must be replaced because of short circuit requirements.

### Generator-Transmission Point of Interconnection

The Facility Study Agreement indicates that [REDACTED] will construct all 161 kV station facilities at their generating site and the 161 kV lines from the generating site to the Point of Interconnection at the Green River 161 kV station. The two lines from the Generator will connect to the Green River 161 kV station at the two points indicated by “Gen” on the diagrams in Appendix D. Interconnection metering will be located at each of these Points of Interconnection.

### Project Costs and Completion Timeframes

The cost and time frame required for the equipment, engineering, procurement and construction of the necessary facilities is shown in Appendix E. The estimated cost to provide the service requested by [REDACTED] is \$72.4 54.5 million without Thoroughbred (scenario 2) and is \$96.4 74.8 million with Thoroughbred. The time required to complete the necessary construction and upgrades is 40 and 36 months, respectively.

### Construction and Upgrades of Other Transmission Owners

Construction of facilities is required by other Transmission Owners for each of the scenarios analyzed. The participation of the other Transmission Owners in the ITO’s SIS process is not considered a commitment by the other Transmission Owners to construct the identified facilities. Agreements must be negotiated with the impacted Transmission Owners before the identified construction and upgrades of E.ON transmission facilities can be considered appropriate, necessary and adequate to provide the service requested by [REDACTED]. Appendix E do not include the cost of or

timeframe necessary to complete the facility upgrades and/or construction required by BREC, EKPC and TVA.

## Appendix A Transmission Contingencies

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 line 0 "08JEFF 138" "11JEFFJC 138" "1" ""  
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 line 0 "11POND C 138" "11TIPTOP 138" "1" ""  
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 line 0 "11RIVR Q 161" "11RQ TAP 161" "1" ""  
 cont  
 line 0 "11RODBRN 138" "11SHARKE 138" "1" ""  
 cont  
 line 0 "11RODBRN 138" "4ROWANCO 138" "1" ""  
 cont  
 line 0 "11S PADU 161" "PADUCATP 161" "1" ""  
 cont  
 line 0 "11SCOTT 138" "11TOYT N 138" "1" ""  
 cont  
 line 0 "11SMITH 345" "11DAV CO 345" "1" ""  
 cont  
 line 0 "11VILEY 138" "11W LEXN 138" "1" ""  
 cont  
 line 0 "14REID 5 161" "14DAVIS5 161" "1" ""  
 cont  
 line 0 "14REID 5 161" "14HM TP5 161" "1" ""  
 cont  
 line 0 "14REID 5 161" "14HMPL5 161" "1" ""  
 cont  
 line 0 "14REID 5 161" "14HOPCO5 161" "1" ""  
 cont  
 line 0 "14COLE 5 161" "14HANCO5 161" "1" ""  
 cont  
 line 0 "14COLE 5 161" "14NATAL5 161" "1" ""  
 cont  
 line 0 "14HANCO5 161" "14DAVIS5 161" "1" ""  
 cont  
 line 0 "14HENDR5 161" "14HM TP5 161" "1" ""  
 cont  
 line 0 "14WILSO7 345" "14REID 7 345" "1" ""  
 cont  
 line 0 "14WILSO7 345" "11DAV CO 345" "1" ""  
 cont  
 line 0 "14COLE 7 345" "11DAV CO 345" "1" ""  
 cont  
 line 0 "14MEADE5 161" "14N.HAR5 161" "1" ""  
 cont  
 line 0 "14HM TP5 161" "14HMPL5 161" "1" ""  
 cont  
 line 0 "COLMNTAP 161" "PADUCATP 161" "1" ""  
 cont  
 line 0 "14LIVIN5 161" "5RNSHW\_S 161" "1" ""  
 cont  
 line 0 "11GAR CO 345" "7JKSMIT2 345" "1" ""  
 cont  
 xfmr 0 "11ALCALD 345" "11ALCALD 161" "1" ""  
 cont

xfmr 0 "11BLUE L 345" "11BLUE L 138" "1" ""  
 cont  
 xfmr 0 "11BLUE L 345" "11BLUE L 161" "1" ""  
 cont  
 xfmr 0 "11BRWN N 345" "11BRWN N 138" "1" ""  
 cont  
 xfmr 0 "11GHENT 345" "11GHENT 138" "1" ""  
 cont  
 xfmr 0 "11GHENT 345" "11GHENT 138" "2" ""  
 cont  
 xfmr 0 "11GR RVR 161" "11GR RVR 138" "1" ""  
 cont  
 xfmr 0 "11GR RVR 161" "11GR RVR 138" "2" ""  
 cont  
 xfmr 0 "11GR RVR 161" "11GR RVR 138" "3" ""  
 cont  
 xfmr 0 "11HARDN 345" "11HARDN 138" "1" ""  
 cont  
 xfmr 0 "11HARDN 345" "11HARDN 138" "2" ""  
 cont  
 xfmr 0 "5MARION 161" "11MARION 138" "1" ""  
 cont  
 xfmr 0 "11MIDDLT 345" "11MIDDLT 138" "1" ""  
 cont  
 xfmr 0 "11MIDDLT 345" "11MIDDLT 138" "2" ""  
 cont  
 xfmr 0 "11MIDDLT 345" "11MIDDLT 138" "3" ""  
 cont  
 xfmr 0 "11MIDDLT 345" "11MIDDLT 138" "4" ""  
 cont  
 xfmr 0 "11MILCRK 345" "11MILCRK 138" "1" ""  
 cont  
 xfmr 0 "11MILCRK 345" "11MILCRK 138" "2" ""  
 cont  
 xfmr 0 "11P WEST 345" "11P WEST 138" "1" ""  
 cont  
 xfmr 0 "11PADDYS 138" "11PADD 3 999" "1" ""  
 cont  
 xfmr 0 "11PADDYS 161" "11PADDYS 138" "1" ""  
 cont  
 xfmr 0 "11PADDYS 161" "11PADDYS 138" "2" ""  
 cont  
 xfmr 0 "11PINEVI 345" "11PINEVI 161" "1" ""  
 cont  
 xfmr 0 "11POCKET 500" "11POCK N 161" "1" ""  
 cont  
 xfmr 0 "11SMITH 345" "11SMITH 138" "1" ""  
 cont  
 xfmr 0 "11TIPTOP 138" "11TIPT M 999" "1" ""  
 cont  
 xfmr 0 "11TRIMBL 345" "11TRIMBL 138" "1" ""  
 cont  
 xfmr 0 "11W LEXN 345" "11W LEXN 138" "1" ""  
 cont  
 xfmr 0 "14REID 5 161" "14REID 7 345" "1" ""  
 cont

xfmr 0 "14REID 5 161" "14REID 7 345" "2" ""  
cont  
xfmr 0 "14COLE 5 161" "14COLE 7 345" "1" ""  
cont  
xfmr 0 "14COLE 5 161" "14COLE 7 345" "2" ""  
cont  
xfmr 0 "14WILSO5 161" "14WILSO7 345" "1" ""  
cont  
xfmr 0 "14WILSO5 161" "14WILSO7 345" "2" ""  
cont  
xfmr 0 "14N.HAR4 138" "14N.HAR5 161" "1" ""  
cont  
line 0 "11GR RVR 161" "5PARADIS 161" "1" ""  
cont  
xfmr 0 "11OHIO C 138" "11OHIO C 69" "1" ""  
cont

**Appendix B**  
**Generation Contingencies**

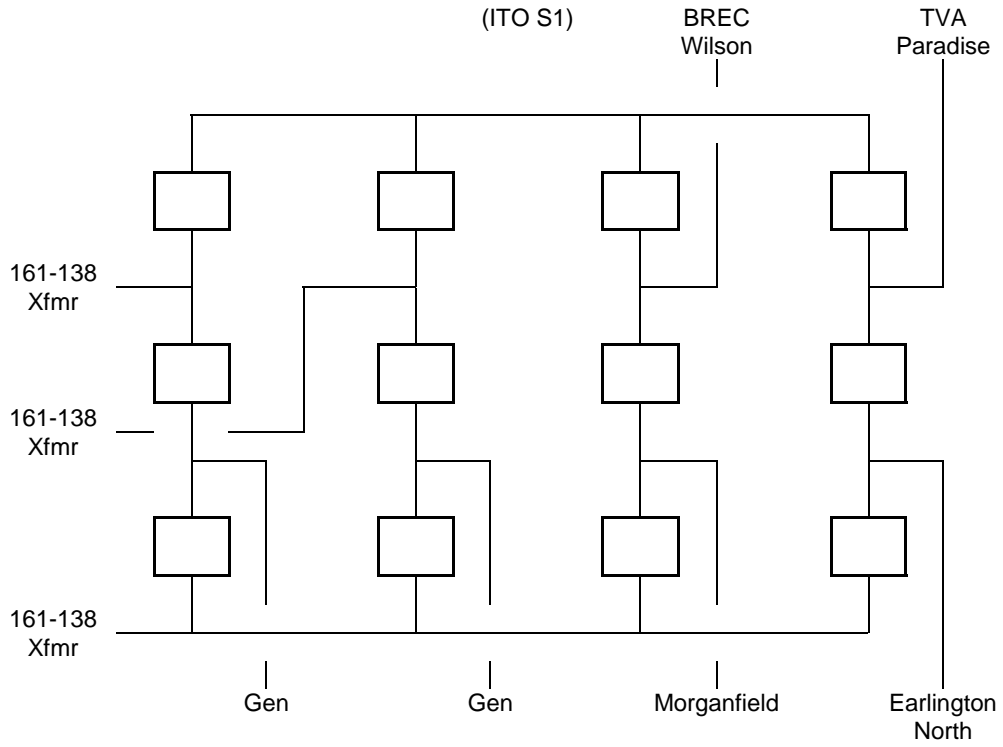
"MC4 import from TVA"  
"BR3 import from TVA"

**Appendix C  
Worst Case Overloads**

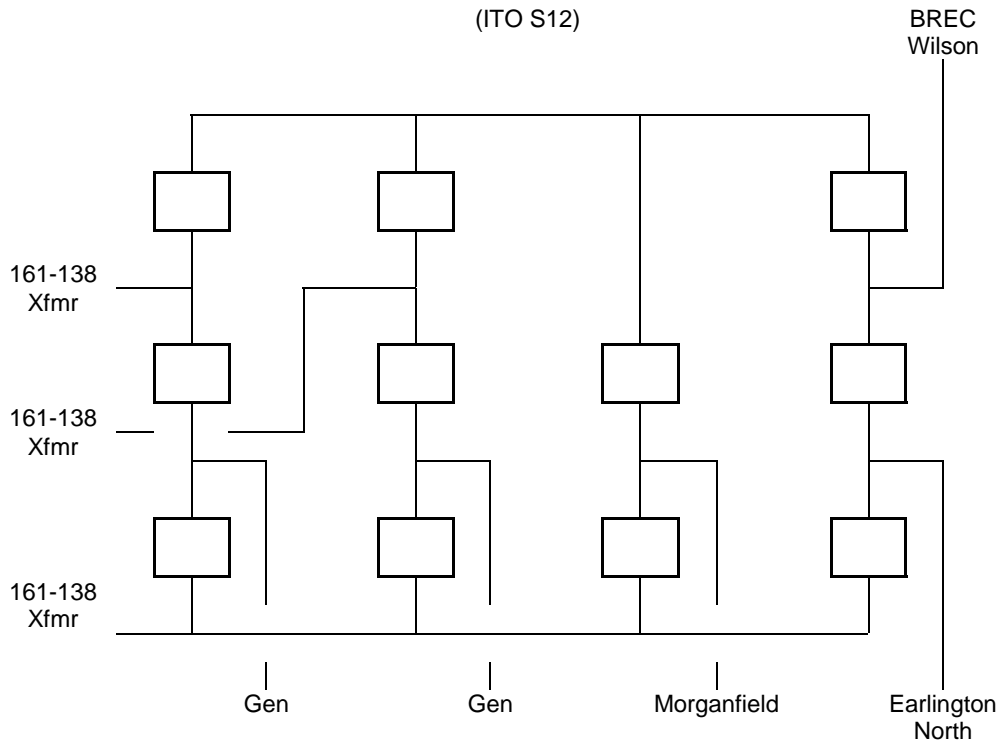
Facility	Contingency	Dispatch	Rating	S1_Max	S12_Max
11CLVRPR 138-11GR STL 138 1	11HARDN 345-11DAV CO 345 1	mc4_tva	220		241.6
11EARL N 161-11RQ TAP 161 1	14WILSO7 345-11DAV CO 345 1	Base	223		248.5
11EASTVW 69-2STEPHNB 69 1	11BONNIE 138-11SHREWS 138 1	br3_tva	48		61.4
11ECHOLS 69-11INDIAN 69 1	11OHIO C 138-11OHIO C 69 1	br3_tva	55	57.1	63.8
11ETOWN 69-11ETWN 4 69 1	Normal - no contingencies	Base	71		72.2
11ETWN 4 69-11HODGEN 69 1	11ETOWN 138-11NELSON 138 1	br3_tva	51	62.9	68.4
11GIBRLT 69-11GR RVR 69 1	11OHIO C 138-11OHIO C 69 1	br3_tva	55		57.5
11GIBRLT 69-11NELSON 69 1	11OHIO C 138-11OHIO C 69 1	br3_tva	55		56.3
11GR RVR 138-11GR STL 138 1	14WILSO7 345-11DAV CO 345 1	mc4_tva	175		290.4
11GR RVR 138-11OHIO C 138 1	11GR RVR 138-11OHIO C 138 2	br3_tva	176	187.2	228.3
11GR RVR 138-11OHIO C 138 2	11GR RVR 138-11OHIO C 138 1	br3_tva	176	192.9	235.1
11GR RVR 161-11RQ TAP 161 1	14WILSO7 345-11DAV CO 345 1	Base	254		295.7
11GR RVR 161-11RQ TAP 161 1	Normal - no contingencies	Base	205		224.7
11HAEFLN 138-11W LEXN 138 1	11VILEY 138-11W LEXN 138 1	br3_tva	274		274.7
11HILLSI 69-11POWDER 69 1	11GR RVR 161-11RQ TAP 161 1	Base	35		35.9
11LEIT C 69-11LEIT E 69 1	11BONNIE 138-11SHREWS 138 1	br3_tva	68		78.8
11LEIT C 69-11LEITCH 69 1	11BONNIE 138-11SHREWS 138 1	br3_tva	86		87.3
11LEITCH 69-11MILLWO 69 1	11OHIO C 138-11SHREWS 138 1	br3_tva	68		68.4
11LEITCH 138-11LEITCH 69 1	11BONNIE 138-11SHREWS 138 1	br3_tva	101		102.4
11OHIO C 69-11RIVRVI 69 1	11OHIO C 138-11OHIO C 69 1	br3_tva	55		57.6
11OHIO C 69-11WARREN 69 1	11OHIO C 138-11SHREWS 138 1	br3_tva	86		96.1
11OHIO C 138-11OHIO C 69 1	11OHIO C 138-11SHREWS 138 1	br3_tva	86	87	100.5
11OHIO C 138-11SHREWS 138 1	14WILSO7 345-11DAV CO 345 1	br3_tva	168		247.5
11OHIO C 138-11SHREWS 138 1	11HARDN 345-11DAV CO 345 1	br3_tva	168	185.4	
11VILEY 138-11W LEXN 138 1	11HAEFLN 138-11W LEXN 138 1	br3_tva	274	276.2	279.2

# Appendix D Proposed Green River 161 kV Station Configuration

## Scenario 2 (ITO S1)



## Scenario 4 (ITO S12)



**Appendix E**  
**Transmission Owners Interconnection Facilities Network Upgrades Cost and Timeframes**

Facility	2008\$	Months	S2-FS	S4-FS
Reconfigure Green River 161 kV	4,300,000	24	5,762,400	5,762,400
Relocate Green River 161 kV lines for 161 kV station reconfiguration	2,442,250	16	3,272,800	3,272,800
Replace 3 Green River 161-138 kV, 120 MVA transformers with 150 MVA units	6,630,000	30	8,884,800	
Replace 3 Green River 161-138 kV, 120 MVA transformers with 200 MVA units	9,330,000	30		12,503,100
Add 161 kV line exit at Green River for the Green River to TVA Paradise 161 kV line	800,000	18	1,072,100	
Construct Green River to TVA Paradise 161 kV line (13.4mi)	19,500,000	40	26,131,900	
Reconductor Green River to River Queen Tap 161 kV with 795 kcm ACSR or 2-266.8 kcm ACSR.	1,898,600	15		2,544,300
Replace 800A Wave Trap at Earlington North with a 1200A to increase capacity of Earlington North-River Queen Tap 161 kV.	70,000	8		93,800
Reconductor Earlington North to River Queen Tap 161 kV with 795 kcm ACSR or 2-266.8 kcm ACSR.	6,030,000	36		8,080,800
Reconductor Green River-Green River Steel 138 kV with 954 kcm ACSR or add 2nd 397.5 kcm ACSR .	8,792,700	36	11,783,100	11,783,100
Replace 1200A breakers at Green River & Green River Steel to increase capacity of Green River-Green River Steel 138 kV line.	360,000	10		482,400
Upgrade 2-397.5 kcm ACSR portion of Cloverport-Green River Steel 138 kV to 176F	5,742,100	36		7,695,000
Replace 500 MCM bus and risers at Cloverport and 500 MCM risers at Green River Steel it increase capacity of Cloverport-Green River Steel 138 kV.	100,000	8		134,000
Upgrade Green River-Ohio Co138 kV ckt1 to 212F	2,600,000	16	3,484,200	
Reconductor Green River-Ohio Co138 kV ckt1 with 795 kcm ACSR or 2-266.8 kcm ACSR.	4,890,000	24		6,553,100
Reconductor Green River-Ohio Co138 kV ckt2 with 795 kcm ACSR or 2-266.8 kcm ACSR.	4,447,200	24		5,959,700
Upgrade Ohio Co-Shrewsbury 138 kV to 212F	4,650,000	24	6,231,400	
Reconductor Ohio Co-Shrewsbury 138 kV with 795 kcm ACSR or 2-266.8 kcm ACSR.	9,750,000	36		13,065,900
Replace 500 MCM Cu bus and risers at Shrewsbury with 750 MCM Cu to increase capacity of Ohio Co-Shrewsbury 138 kV.	60,000	8		80,400
Install 0.5% reactor in the West Lexington to Viley Road 138 kV at West Lexington	350,000	12		469,000
Install 0.5% reactor in the West Lexington to Haefling 138 kV at West Lexington	350,000	12		469,000
Replace two 69 kV 600A disconnects to increase capacity of Ohio Co 138-69 kV.	75,000	8	100,500	100,500
Reset 69 kV bus differential CTs to increase capacity of Leitchfield 138-69 kV	40,000	8		53,600
Upgrade Eastview-Stephensburg 69 kV to 212F	449,800	10		602,800
Upgrade Elizabethtown-Elizabethtown 4 69 kV to 212F	1,056,650	10	1,416,000	1,416,000

