

PJM Generator Interconnection Request
Queue T107 Essex (Hess) 230kV
Facilities Study Report

Docs # 704606

June 2012

LIMITATIONS

In the preparation of this report, the information provided to Burns & McDonnell by other entities was used by Burns & McDonnell to make certain assumptions with respect to conditions, which may exist in the future. While Burns & McDonnell believes the assumptions made are reasonable for the purposes of this report, Burns & McDonnell makes no representation that the conditions assumed will, in fact, occur. In addition, while Burns & McDonnell has no reason to believe that the information provided by others, and on which this report is based, is inaccurate in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee its accuracy or completeness. To the extent that actual future conditions differ from those assumed herein or from the information provided to Burns & McDonnell, the actual results will vary from those presented.

TABLE OF CONTENTS

	<u>Page No.</u>
EXECUTIVE SUMMARY	1
1. INTRODUCTION.....	2
1.1 DESCRIPTION OF PROJECT.....	2
1.2 AMENDMENTS TO THE IMPACT STUDY REPORT	3
1.3 SCOPE OF INTERCONNECTION CUSTOMER’S WORK	4
1.4 SCOPE OF PSE&G WORK.....	4
1.4.1 DIRECT CONNECTION.....	4
1.4.2 NETWORK UPGRADES	4
2. FACILITY UPGRADES	6
2.1 SUBSTATIONS.....	6
2.1.1 ESSEX 230/138 kV SUBSTATION	6
2.1.2 MARION 138 kV SUBSTATION	9
2.1.3 BERGEN 230 kV SUBSTATION	10
2.1.4 ECRR 138 kV SUBSTATION.....	11
2.1.5 ATHENIA 230 kV SUBSTATION	12
2.2 UNDERGROUND TRANSMISSION LINES.....	12
2.2.1 BAYWAY TO FEDERAL SQUARE 138 kV UNDERGROUND LINE (K-1311)	13
2.2.2 ATHENIA TO BERGEN 230 kV UNDERGROUND LINE (FUTURE)	15
2.3 OVERHEAD TRANSMISSION LINES.....	18
2.3.1 KEARNY TO MARION 138 kV OVERHEAD LINE (N-1314).....	18
2.3.2 ESSEX TO HUDSON 230 kV OVERHEAD LINE (A-2227)	19
3. SUMMARY.....	21
3.1 TOTAL COST SUMMARY.....	21
3.2 PROJECT SCHEDULE SUMMARY	21

LIST OF TABLES

TABLE E-1: SUBSTATION UPGRADES – COST ESTIMATES	1
TABLE E-2: T107 FACILITIES UPGRADE - PROJECT SCHEDULES	2
TABLE 1-1: TRANSMISSION LINE AND TRANSFORMER UPGRADES	5
TABLE 1-2: CIRCUIT BREAKER UPGRADES	5
TABLE 2-1: ESSEX 230 kV SUBSTATION UPGRADE - COST ESTIMATE.....	8
TABLE 2-2: ESSEX 230 kV AND 138 kV SUBSTATION UPGRADE - PROJECT SCHEDULE.....	9
TABLE 2-3: MARION 138 kV SUBSTATION UPGRADE - COST ESTIMATE	9
TABLE 2-4: BERGEN 230 kV SUBSTATION UPGRADE - COST ESTIMATE.....	10
TABLE 2-5: ECRR 138 kV SUBSTATION UPGRADE - COST ESTIMATE.....	11
TABLE 2-6: ECRR 138 kV SUBSTATION UPGRADE – PROJECT SCHEDULE.....	11
TABLE 2-7: ATHENIA 230 kV SUBSTATION UPGRADE - COST ESTIMATE	12
TABLE 2-8: BAYWAY TO FEDERAL SQUARE 138 kV U/G LINE – EXISTING CIRCUIT PARAMETERS.....	13
TABLE 2-9: BAYWAY TO FEDERAL SQUARE 138 kV U/G LINE - REQUIRED CABLE RATINGS	13
TABLE 2-10: BAYWAY TO FEDERAL SQUARE 138 kV U/G LINE UPGRADE - COST ESTIMATE.....	14
TABLE 2-11: BAYWAY TO FEDERAL SQUARE 138 kV U/G LINE UPGRADE - PROJECT SCHEDULE.....	15
TABLE 2-12: ATHENIA TO BERGEN 230 kV U/G LINE - REQUIRED RATINGS	15
TABLE 2-13: ATHENIA TO BERGEN 230 kV U/G LINE – PROPOSED CIRCUIT PARAMETERS.....	15
TABLE 2-14: ATHENIA TO BERGEN 230 kV U/G LINE – UPGRADE OPTIONS	16
TABLE 2-15: ATHENIA TO BERGEN 230 kV U/G LINE UPGRADE - COST ESTIMATE.....	17
TABLE 2-16: ATHENIA TO BERGEN 230 kV U/G LINE & SUBSTATION UPGRADE - PROJECT SCHEDULE ..	18
TABLE 2-17: KEARNY TO MARION 138 kV O/H LINE REBUILD - COST ESTIMATE.....	19
TABLE 2-18: KEARNY TO MARION 138 kV SUBSTATION & O/H LINE REBUILD - PROJECT SCHEDULE	19
TABLE 2-19: ESSEX TO HUDSON 230 kV O/H LINE UPGRADE - COST ESTIMATE.....	20
TABLE 2-20: ESSEX TO HUDSON 230 kV O/H LINE & SUBSTATION UPGRADE - PROJECT SCHEDULE	20
TABLE 3-1: T107 FACILITIES UPGRADE – ALLOCATED COST ESTIMATES	21
TABLE 3-2: T107 FACILITIES UPGRADE - PROJECT SCHEDULES	22

LIST OF FIGURES

FIGURE 1-1: T107 INTERCONNECTION AT ESSEX 230/138 kV SUBSTATION	3
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APPENDICES

APPENDIX A: GENERAL DESIGN CRITERIA

APPENDIX B: BILL OF MATERIALS

APPENDIX C: PROJECT SCHEDULES

APPENDIX D: BAYWAY – FEDERAL SQUARE UNDERGROUND CABLE CALCULATIONS

APPENDIX E: ATHENIA – BERGEN UNDERGROUND CABLE EVALUATION

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EXECUTIVE SUMMARY

Hess Corporation (Hess) proposes a 625 MW gas-fired, 2x1, combined cycle generating facility comprised of General Electric 7FA combustion turbines and a General Electric steam turbine connecting to the Public Service Electric and Gas (PSE&G) Essex 230kV substation. The combined cycle plant is to be located at the Hess Newark terminal, a 39 acre site, at Doremus Avenue and Delancy Street in Essex County, Newark, New Jersey. The request is identified as PJM Generator Interconnection Request Queue #T107 (T107) with a projected in-service date of May 31, 2015.

This T107 Facilities Study was performed to examine the PSE&G facilities that were identified in the T107 System Impact Study¹ and the project requirements for each of the facilities. The total cost of the PSE&G facilities upgrades required for the interconnection of T107 including engineering, materials, construction and PSE&G direct costs and contingency is estimated at \$274,463,940. The total cost allocated to the T107 project is \$40,250,160 as shown in section 3.1. The total substation, underground and overhead transmission line costs are provided in [Table E-1](#), [Table E-1](#), and [E-3 2](#) respectively. The upgrade costs that will be partially allocated to T107 are indicated in each table.

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Table E-1: Substation Upgrades – Cost Estimates

Network Upgrade #	Facility Name	Project Description	Total Cost with Contingency
N3301	Essex Three-Breaker Bay Bay Expansion less one Breaker (No Control House Allocation in this item)	T107 termination at the Essex 230 kV substation. Relocation of one of the Essex 230/138 kV transformer terminations	\$6,847,680
N2080	Essex 230/138kV Transformer #1	Replace transformer to achieve the 616/824 MVA normal/emergency ratings	\$15,290,880
N1235	Essex 138 kV Breaker 3 LM	Upgrade Breakers to 80 kA Interrupting Rating	\$1,423,600
N1233	Essex 138 kV Breaker 1 PM		\$1,423,600
N1232	Essex 138 kV Breaker 3 PM		\$1,423,600
N1236	Essex 230kV Breaker 22 H		\$1,658,000
N1237	Essex 138kV Breaker 4LM		\$1,491,600
N0984	Bergen 230 kV Breaker 12 H		\$1,658,000
N2079	Essex-Hudson 230 kV		<u>\$13,872,000</u> <u>\$1,658,000</u>
N0985	Athenia 230 kV Breaker 21 H*		\$1,658,000
N0986	Athenia 230 kV Breaker 11 H*		\$1,658,000
N0987	Athenia 230 kV Breaker 51 H*		<u>\$1,658,000</u> <u>\$1,500,000</u>
Total Substation Costs			<u>\$37,690,960</u><u>50,062,960</u>

*Upgrade costs will be partially allocated to T107

¹ PJM Generator Interconnection Request Queue #T107 Essex (Hess) 230 kV Impact Study (2nd Re-Tool) – 6/8/12.

Table E-2: T107 Facilities Upgrade - Project Schedules

Construction Schedule Package	Package Descriptions	Network Upgrades # Included in Package	Substation Upgrades Included in Package	Start Date	End Date
1	Essex 230 kV and 138 kV Substation Package: Essex 230kV 3-breaker bay expansion Essex 230kV & 138 kV breaker Upgrades Essex 230/138kV Transformers #1	N3301, N1235, N1233, N1232, N1237 & N1236	Essex 230kV 3-breaker Bay Expansion, Essex 138 & 230 kV breakers, 3LM, 4LM, 1PM, 3PM, & 22H, and 1-Essex 230/138kV transformers	June 2012	January 2015
2	ECRR 138kV Substation	N1405 & N1406	NOT REQUIRED	April 2014	April 2015
3	Athenia - Bergen 230kV Underground Line	N2135	NOT REQUIRED	January 2012	April 2015
3a	Athenia - Bergen 230kV Substations	N0984, N0985, N0986 & N0987	Bergen 230 kV breakers , 12H and Athenia 230kV breakers 21H, 11H & 51H	June 2012	December 2014
4	Bayway – Federal Square 138 kV Underground Line*	N2136	TO BE DONE BY PSE&G	January 2012	April 2015
5					
6	Essex - Hudson 230kV Overhead Line	N2079	None	July 2012	February 2014
Overall T107 Project Schedule				January 2012	April 2015

*The Bayway – Federal Square 138 kV underground line HPFF conductor lead time for procurement was assumed to be 20 months.

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1. INTRODUCTION

1.1 DESCRIPTION OF PROJECT

Hess Corporation (Hess) proposes a 625 MW gas-fired, 2x1, combined cycle generating facility comprised of General Electric 7FA combustion turbines and a General Electric steam turbine connecting to the Public Service Electric and Gas (PSE&G) Essex 230kV substation. The combined cycle plant is to be located at the Hess Newark terminal, a 39 acre site, at Doremus Ave. and Delancey Street in Essex County, Newark, New Jersey. The request is identified as PJM Generator Interconnection Request Queue #T107 (T107) with a projected in-service date of May 31, 2015.

T107 is located approximately one mile from the Essex substation. A new generator tie line approximately 1 mile long is required to interconnect T107 to the Essex substation. Hess plans to install the new generator tie line cable adjacent to abandoned oil pipeline owned by Hess. The abandoned pipeline goes directly to the Essex facility and will need to extend up PSE&G right of way to interconnect T107 to the Essex substation.

The purpose of this Facilities Study is to examine the PSE&G facilities identified in the T107 System Impact Study² as system constraints and define the project requirements for each of these

² PJM Generator Interconnection Request Queue #T107 Essex (Hess) 230 kV Impact Study (2nd Re-Tool) – 06/08/12 .

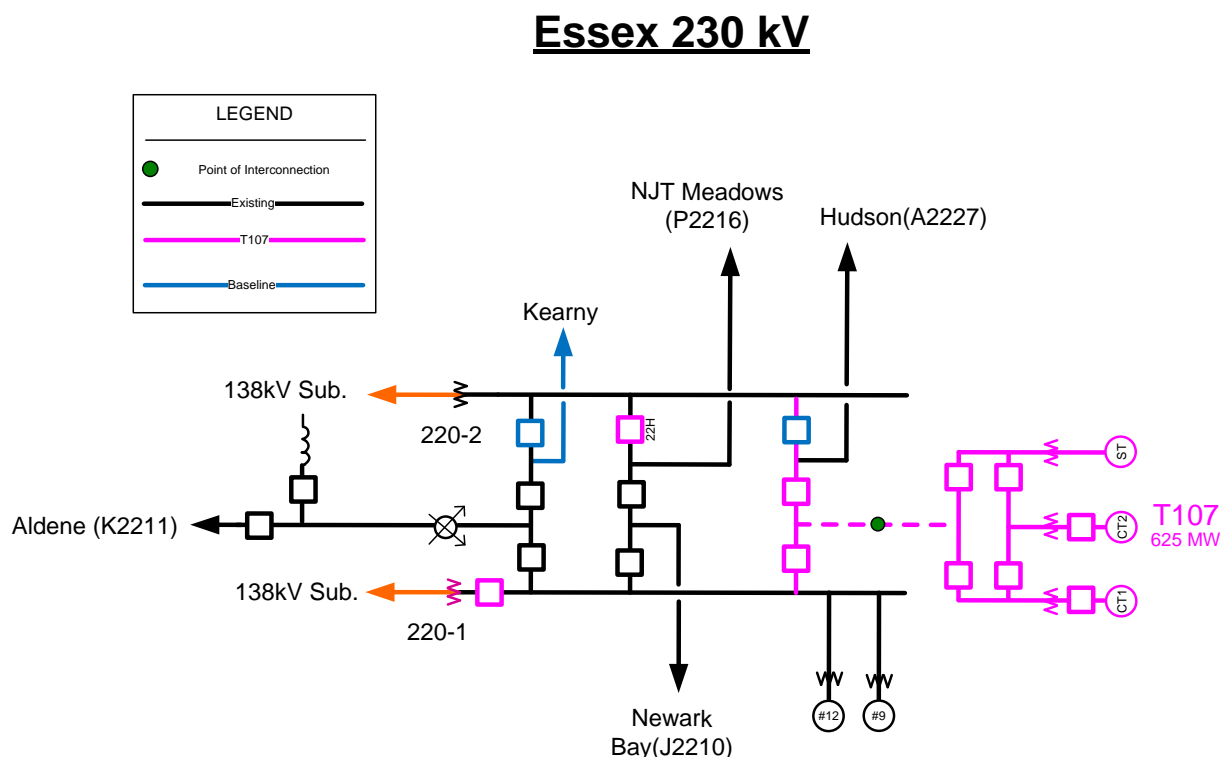
facilities to mitigate the constraints. This Facilities Study shall identify the purpose and necessity; provide preliminary cost estimates; and develop a preliminary schedule for each of the facilities.

Figure 1-1

Figure 1-1 shows the future termination of T107 at the Essex 230/138 kV substation. Details of the direct connection and network upgrades required for the T107 interconnection are provided in Section **1.41.4**.

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Figure 1-1: T107 Interconnection at Essex 230/138 kV Substation



Note: The Point of Interconnection (POI) shall be at the terminals of the pothead rack for the radial transmission cable constructed by Hess for the generating site to the Essex Switching Station.

1.2 AMENDMENTS TO THE IMPACT STUDY REPORT

The following changes were made to the Impact Study report issued February 2011 upon which the Facilities Study Agreement was based.

- PSE&G decided to complete the Bayway-Federal Square 138kV upgrade #n2136 at their cost as Supplemental Project #s0309.
- Re-tool showed the ECRR 138kV circuit breakers 901 and 902 to be below their interrupting duty and do not need to be replaced.
- Re-tool showed the Marion 138kV circuit breakers 5PM and 8PM to be below their interrupting duty and do not need to be replaced.

- Re-tool showed the Conastone-Mt.Carmel 2322 230kV circuit to not be overloaded by the T107 project.
- Re-tool showed the Mt.Carmel 2322-Northwest 230kV circuit to not be overloaded by the T107 project.
- Re-tool showed the North Meshoppen #3 230/115kV transformer to not be overloaded by the T107 project.
- Re-tool showed the Graceton-Bagley 230kV circuit to not be overloaded by the T107 project.
- Retool showed the Essex 230/138kV transformer #2, not to be overloaded by the project. (n1602).
- Retool showed that the Essex 138kV circuit breakers 1BM and 2 BM to be below their interrupting duty and do not need to be replaced.
- Retool showed the Essex 138 kV 4LM breaker to be overdutied and was added to the scope of work for this project (n1237)

1.3 SCOPE OF INTERCONNECTION CUSTOMER'S WORK

As the developer, Hess will build the radial transmission circuit from the generation site to Essex Switching Station. Hess will engineer, procure and construct the interconnection cable required to interconnect T107 generation plant to the termination structure at PSE&G Essex 230 kV substation.

1.4 SCOPE OF PSE&G WORK

The interconnection of T107 requires the following direct connection and network system upgrades to the PSE&G facilities.

1.4.1 Direct Connection

The direct connection upgrades required for the interconnection of T107 include the construction of a new 230 kV 3-breaker bay at the Essex 230/138 kV substation. The new 3-bay will only require two breaker installations to accommodate the project. The T107 interconnection cable, that will be engineered, procured and constructed by Hess, will be connected to a new terminal position in the new 3-breaker bay at the Essex substation. In addition, one of the Essex 230/138 kV transformer connections to the Essex 138kV station will be moved from the main bus to a new position in the new bay. Revenue metering for this project will be at the Essex substation.

1.4.2 Network Upgrades

The network upgrades identified in the System Impact Study for the interconnection of T107 are listed in [Table 1-1](#) and [Table 1-2](#) below.

[Table 1-1](#) shows the required transmission line and transformer upgrades.

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Table 1-1: Transmission Line and Transformer Upgrades

Network Upgrade #	Facility Name	Project Description	Cost Allocation
N2079	Essex - Hudson 230kV Overhead Line	Reconductor circuit with 1590 ACSS conductor to achieve ratings of 800/1050 MVA summer normal/emergency ratings	Full
N2080	Essex 230/138kV Transformer #1	Replace transformer with 370/493/616 MVA transformer to achieve the 616/824 MVA normal/emergency rating requirements	Full

Table 1-2 shows the circuit breaker upgrades required to accommodate T107. The full and partial circuit breaker cost allocations will be dependent on the contribution of the T107 to the overdutied condition of the circuit breakers.

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Table 1-2: Circuit Breaker Upgrades

Network Upgrade #	Substation Name/Voltage	Circuit Breaker #	Project Description	T107 Cost Allocation
N1237	Essex 138 kV	4LM	Replace circuit breakers and associated breaker disconnect switches to 80 kA interrupting rating	Full
N1235		3 LM		Full
N1233		1 PM		Full
N1232		3 PM		Full
N1236	Essex 230 kV	22 H		Full
N0984	Bergen 230 kV	12 H		Partial
N0985	Athenia 230 kV	21 H		Partial
N0986		11 H		Partial
N0987		51 H		Partial

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2. FACILITY UPGRADES

The following sections describe the facilities upgrades required for the interconnection of T107, the corresponding cost estimates and the project construction schedules.

2.1 SUBSTATIONS

The Essex 230/138 kV, Bergen 230 kV, and Athenia 230 kV substations have to be upgraded to accommodate T107. The general assumptions made in the design and cost estimate of the substation facility upgrades are as follows:

1. Cost estimates were based on 2011 dollars, no escalation or discount rates were included.
2. Costs adjusted to Newark, NJ city cost index.
3. No state taxes included.
4. Contingency costs were assumed to be 20% of the total engineering, material and construction costs.
5. Direct costs for PSE&G are included at 12% of base cost (total cost without contingency).
6. Assumed all new equipment will fit in the existing footprint of the existing substations. No additional land acquisition will be required for any of the upgrades.
7. Engineering fee for study to determine adequacy of breaker foundations and to design replacement foundations is included. The resulting costs of engineering, materials and construction for foundation upgrades are not included.
8. Engineering fee for study to determine the adequacy of the existing relay and protection schemes and the fee for upgrade design is included. The resulting costs of engineering, materials and construction for protection upgrades are not included.
9. Engineering fee for a study to determine the adequacy of the existing lightning protection scheme and the design of lightning protection upgrade is included. The resulting costs of engineering, materials and construction for lightning protection upgrades are not included.
10. Engineering fee for substation grounding study and upgrade design is included. The resulting costs of engineering, materials and construction for grounding upgrades are not included (except Essex substation, see Section [2.1.12.1.1](#)).
11. Engineering fee for study to determine the adequacy of the existing bus, bus supports, structures and foundations under 80 kA fault conditions and the fee for upgrade design is included. The material and construction costs of the results of the bus study cannot be known and have not been included (except Essex substation, see Section [2.1.12.1.1](#)).

2.1.1 Essex 230/138 kV Substation

A new 230 kV 3-breaker bay less one breaker will be added to the Essex 230 kV substation. The T107 interconnection cable will terminate at one of the new positions on the new 3-breaker bay. The Essex 230/138 kV #1 transformer connection will need to be replaced along with the addition of a breaker to connect to the substation bus.

The Essex 230/138 kV substation has two 230/138 kV transformers, transformer #1 and transformer #2, with emergency ratings of 573 MVA and 457 MVA, respectively. Only

transformer #1 overloads during separate multiple contingency conditions. The #1 transformer will need to be replaced with a new transformer with normal and emergency ratings of 616 MVA and 824 MVA respectively.

The Essex 230/138 kV transformers are assumed to have a normal ONAN/ONAF/OFAF rating of 370/493/616 MVA to achieve the 616/824 MVA normal/emergency rating requirement. A typical power transformer may be loaded to an emergency rating of 824 MVA (133%) with some varying loss of insulation life for short and long durations.

In addition to replacing the #1 Essex 230/138 kV transformer, several 138 kV and 230 kV circuit breakers at Essex will also have to be upgraded. The Essex 138 kV circuit breakers 3LM, 4LM, 1PM, 3PM and the Essex 230 kV 22H circuit breakers will have to be upgraded to 80 kA breaker interrupting rating along with their associated breaker disconnect switches. A site walk down has revealed that the existing control building cannot accommodate any more equipment. Work scope and cost will be developed during the construction phase and managed through a scope change.

2.1.1.1 Cost Estimate Assumptions

In addition to the general cost estimate assumptions listed in Section [2.12.1](#), the following specific assumptions apply to the design and cost estimates of the Essex 230 kV substation upgrades:

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1. *Essex 3-Breaker Bay AC/DC System Study* is included
2. One incoming line position will be for the T107 connection utilizing an underground Hess line.
3. All line relaying will be optical fiber differential type relaying.
4. Engineering fee for grounding study and grounding upgrade design based on assumed 15' x 15' ground grid has been included for Essex 230 kV and 138 kV substations.
5. Construction and material costs have been included for 15' x 15' ground grid upgrade.
6. One strain bus takeoff structures from the 230 kV yard for 230/138 kV #1 transformer will be removed and relocated. Engineering fees and material and procurement costs are included.
7. Engineering fee and material and construction costs for foundations for new 230 kV breakers, line position and cable termination structure are included.

Essex 230/138kV Transformers #1 Engineering fee, material and construction costs for one three phase 370/493/616 MVA transformer and one spare are included

1. The cost of a new transformer foundation is included.
2. Strain bus takeoff structures in the 230 kV and 138 kV yards need to be removed and relocated. Engineering fee and material and construction costs are included.
3. New control cable will be pulled for the transformer.
4. A dead tank breaker combo unit will be installed on the high side of the transformer.
5. Transformer #1 will be connected to the 230 KV bus. On the low side of transformer #1, the takeoff structure will need to be analyzed. The cost associated with the required

upgrades is not included in this estimate. A site walk down has revealed that a new take off structure may be required to accommodate additional equipment.

6. The #1 transformer will be engineered by the same A/E firm under the same contract and the construction will be performed by one construction contractor.
7. Engineering fee for transformer surge protection study and design, and material and construction costs are included.
8. Engineering fee for study to determine the adequacy of the existing transformer relay and protection schemes and the fee for upgrade design is included. The material and construction costs cannot be known and is not included.

Existing 138 kV Oil Circuit Breaker (OCB) and Gas Circuit Breaker (GCB) Replacements

1. For OCB Breakers, new control cable will be utilized for each new breaker.
2. For GCB Breakers, existing control cable will be utilized for each new breaker by adding a cable junction box.
3. No AC/DC system studies were included.

2.1.1.2 Cost Estimate

Table 2-1 below shows the cost estimates for the new three-breaker bay, one three-phase 230/138 kV transformer and circuit breakers at the Essex 230 kV and 138 kV substations. The total cost for all the upgrades at the Essex 230/138 kV substation is estimated at \$46,083,840. The engineering fee, material costs and construction costs are based on current PSE&G 230 kV and 138 kV projects.

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Table 2-1: Essex 230 kV Substation Upgrade - Cost Estimate

Network Upgrade #	Essex 230/138 kV Substation Upgrades	Engineering Fee	Material Cost	Construction Cost	Contingency	PSE&G Direct Costs	Total
N3301	Essex 230kV Three Breaker Bay Expansion	\$121,000	\$1,406,600	\$3,432,000	\$1,264,800	\$623,280	\$5,582,880
N2080	Essex 230/138kV Transformer #1 Replacement	\$173,000	\$10,279,000	\$1,132,000	\$2,316,800	\$1,390,080	\$12,974,080
N1236	Essex 230kV Breaker 22H (Currently GCB)	\$141,000	\$659,400	\$564,000	\$158,000	\$135,600	\$1,500,000
N1237	Essex 138kV Breaker 4LM(Currently OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,265,600
N1235	Essex 138kV Breaker 3LM (Currently GCB)	\$141,000	\$425,000	\$564,000	\$158,000	\$135,600	\$1,265,600
N1233	Essex 138kV Breaker 1PM (Currently GCB)	\$141,000	\$425,000	\$564,000	\$158,000	\$135,600	\$1,265,600
N1232	Essex 138kV Breaker 3PM (Currently GCB)	\$141,000	\$425,000	\$564,000	\$158,000	\$135,600	\$1,265,600
Total PSE&G Direct Costs							
Total Essex Substation Cost Estimate without Contingency							\$25,119,360
Total Essex Substation Cost Estimate							\$29,558,960

2.1.1.3 Schedule

The project schedules for the breakers (3 LM, 4 LM, 1 PM & 3 PM) at the Essex 138 kV substation, the Essex 230 kV 3-breaker bay expansion, the Essex 230 kV 22H breaker replacement and the Essex #1 230/138 kV transformer were combined into the Essex Substation

construction schedule package. The schedules for the different phases of upgrade projects at the Essex 230/138 kV substation are shown in Table 2-2 below.

Table 2-2: Essex 230 kV and 138 kV Substation Upgrade - Project Schedule

Project Phase	Revised Start Date	Revised Finish Date
Notice to Proceed	June 2012	June 2012
Engineering Design	September 2012	March 2013
Permitting	June 2012	July 2013
Materials Procurement	October 2012	October 2013
Construction	July 2013	January 2015
Total Substation Project	March 2012	January 2015

2.1.2 Marion 138 kV Substation

(The work described in this section is not required for interconnection of the T107 project)

The T107 contributes to the overdutied conditions of the Marion 138 kV 8PM and 5PM circuit breakers. These breakers along with the associated breaker disconnect switches will have to be upgraded to a breaker interrupting rating of 80 kA.

2.1.2.1 Cost Estimate Assumptions

In addition to the general cost estimate assumptions listed in Section 2.1, the following specific assumptions apply to the design and cost estimates of the Marion 138 kV substation:

1. For OCB Breakers, new control cable will be utilized for each new breaker.
2. No AC/DC system studies were included in the cost estimate.

2.1.2.2 Cost Estimate

Table 2-3 below shows the cost estimates for the new circuit breakers at the Marion 138 kV substation. The total cost for all the upgrades at the Marion 138 kV substation is estimated at \$2,983,200. The basis for the engineering fee, material costs and construction costs are current PSE&G 138 kV projects.

Table 2-3: Marion 138 kV Substation Upgrade - Cost Estimate

Network Upgrade #	Marion 138 kV Substation Upgrades	Engineering Fee	Material Cost	Construction Cost	Contingency	PSE&G Direct Costs	Total
N1425	Marion 138kV Breaker 8PM (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
N1426	Marion 138kV Breaker 5PM (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
Total PSE&G Direct Costs						\$271,200	
Total Marion Substation Cost Estimate without Contingency							\$2,531,200
Total Marion Substation Cost Estimate							\$2,983,200

2.1.2.3 Schedule

The construction schedule for the Marion 138 kV breakers is included in the Kearny – Marion 138 kV overhead line construction schedule package as described in Section 2.3.1.3 below.

2.1.3 Bergen 230 kV Substation

(Only the work described for N0984, the 12H Breaker, is required for interconnection of the T107 project)

The T107 contributes to the overdutied conditions of the Bergen 230 kV 11H, 20H and 12H circuit breakers. These breakers along with the associated breaker disconnect switches will have to be upgraded to a breaker interrupting rating of 80 kA. Work scope at Bergen is now an 80 kA Gas Insulated Substation (GIS) and costs for one breaker will be assigned to T107.

2.1.3.1 Cost Estimate Assumptions

In addition to the general cost estimate assumptions listed in Section 2.12.1, the following specific assumptions apply to the design and cost estimates of the Bergen 230 kV substation:

1. For OCB Breakers, new control cable will be utilized for each new breaker.
2. For GCB Breakers, existing control cable will be utilized for each new breaker by adding a cable junction box.
3. The cost of AC/DC system studies was not included in the cost estimate.

2.1.3.2 Cost Estimate

Table 2-4 below shows the cost estimates for the new circuit breakers at the Bergen 230 kV substation. The total cost for all the upgrades at the Bergen 230 kV substation is estimated at \$4,026,000. The engineering, material and construction cost estimates are based on current PSE&G 230 kV projects.

Table 2-4: Bergen 230 kV Substation Upgrade - Cost Estimate

Network Upgrade #	Bergen 230 kV Substation Upgrades	Engineering Fee	Material Cost	Construction Cost	Contingency	PSE&G Direct Costs	Total
N1403	Bergen 230kV Breaker 11H (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
N1404	Bergen 230kV Breaker 20H (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
N0984*	Bergen 230kV Breaker 12H (Assume GCB)	\$141,000	\$659,000	\$564,000	\$158,000	\$135,600	\$1,500,000
Total PSE&G Direct Costs						\$406,800	
Total Bergen Substation Cost Estimate without Contingency							\$4,483,200
Total Bergen Substation Cost Estimate							\$4,890,000

*Upgrade costs will be partially allocated to T107

2.1.3.3 Schedule

The construction for the Bergen 230 kV breakers is ongoing as work was triggered by a previous project. The original Athena – Bergen 230 kV underground line construction schedule as shown in Section 2.2.2.32.2.2.3 will change.

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2.1.4 ECRR 138 kV Substation

(The work described in this section is not required for interconnection of the T107 project)

The T107 contributes to the overdutied conditions of the ECRR 138 kV 901 and 902 circuit breakers. These breakers along with the associated breaker disconnect switches will have to be upgraded to accommodate the required breaker interrupting rating of 80 kA.

In addition to the general cost estimate assumptions listed in section 2.1, the following specific assumptions apply to the design and cost estimates of the ECRR 138 kV substation:

1. For OCB Breakers, new control cable will be utilized for each new breaker.
2. The cost of AC/DC system studies was not included.

2.1.4.1 Cost Estimate

Table 2-5 below shows the cost estimates for the new circuit breakers at the ECRR 138 kV substation. The total cost for all the upgrades at the ECRR 138 kV substation is estimated at \$2,983,200. The basis for the engineering fee, material costs and construction costs are current PSE&G 138 kV projects.

Table 2-5: ECRR 138 kV Substation Upgrade - Cost Estimate

Network Upgrade #	ECRR 138 kV Substation Upgrades	Engineering Fee	Material Cost	Construction Cost	Contingency	PSE&G Direct Costs	Total
N1405	ECRR 138kV Breaker 901 (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
N1406	ECRR 138kV Breaker 902 (Assume OCB)	\$141,000	\$425,000	\$564,000	\$226,000	\$135,600	\$1,491,600
PSE&G Direct Costs						\$271,200	
Total ECRR Substation Cost Estimate without Contingency							\$2,531,200
Total ECRR Substation Cost Estimate							\$2,983,200

2.1.4.2 Schedule

The construction schedule for all the upgrades at the ECRR 138 kV Substation is shown in Table 2-6 below.

Table 2-6: ECRR 138 kV Substation Upgrade – Project Schedule

Project Phase	Start Date	Finish Date
Notice to Proceed	April 2014	April 2014
Engineering Design	April 2014	August 2014
Materials Procurement	August 2014	February 2015
Construction	February 2015	April 2015
Total Substation Project	April 2014	April 2015

2.1.5 Athena 230 kV Substation

The T107 project contributes to the overdutied conditions of the Athena 230 kV 21H, 11H and 51H circuit breakers. These breakers along with the associated breaker disconnect switches will have to be upgraded to accommodate the required breaker interrupting rating of 80 kA.

2.1.5.1 Cost Estimate Assumptions

In addition to the general cost estimate assumptions listed in section [2.12.1](#), the following specific assumptions apply to the design and cost estimates of the Athena 230 kV substation:

1. For GCB Breakers, existing control cable will be utilized for each new breaker by adding a cable junction box.
2. No AC/DC system studies have been included.

2.1.5.2 Cost Estimate

[Table 2-7](#) below shows the cost estimates for the new circuit breakers at the Athena 230 kV substation. The total cost for all the upgrades at the Athena 230 kV substation is estimated at \$3,128,400. The basis for the engineering fee, material costs and construction costs are current PSE&G 138 kV projects.

Table 2-7: Athena 230 kV Substation Upgrade - Cost Estimate

Network Upgrade #	Athenia 230 kV Substation Upgrades	Engineering Fee	Material Cost	Construction Cost	Contingency	PSE&G Direct Costs	Total
N0985*	Athenia 230kV Breaker 21H (Currently GCB)	\$141,000	\$659,400	\$564,000	\$158,000	\$135,600	\$1,500,000
N0986*	Athenia 230kV Breaker 11H (Currently GCB)	\$141,000	\$659,400	\$564,000	\$158,000	\$135,600	\$1,500,000
N0987*	Athenia 230kV Breaker 51H (Currently GCB)	\$141,000	\$659,400	\$564,000	\$158,000	\$135,600	\$1,500,000
PSE&G Direct Costs						\$406,800	
Total Athena Substation Cost Estimate (without Contingency)							\$4,500,000
Total Athena Substation Cost Estimate							\$4,906,800

*Upgrade costs will be partially allocated to T107

2.1.5.3 Schedule

The construction for the Athena 230 kV breakers is ongoing as work was triggered by a previous project. The original Athena – Bergen 230 kV underground line construction schedule as shown in Section [2.2.2.32.2.2.3](#) will change.

2.2 UNDERGROUND TRANSMISSION LINES

(The network upgrade for Bayway – Federal Square will be done by PSE&G as Supplemental Project #s0309 and Athena –Bergen is no longer required)

The following sections summarize the Bayway to Federal Square 138 kV and Athena to Bergen 230 kV underground line upgrades recommended in the T107 System Impact Study. Also included are details of the design and cost assumptions, cost estimates and construction schedule for each of the underground cables.

The general assumptions made in the design and cost estimate of the Bayway to Federal Square 138 kV and Athena to Bergen 230 kV underground line upgrades are as follows:

1. Cost estimates were based on 2011 dollars, no escalation or discount rates were included.
2. Costs adjusted to Newark, NJ city cost index.
3. No state taxes included.
4. No real estate or land acquisition costs included.
5. Contingency was assumed to be 40% of the total material and labor costs (excluding PSE&G direct costs).
6. A thermal study will be required to confirm the ratings and the cost were included in the engineering fee estimate.
7. Engineering and construction management costs are assumed to be 10% of base cost (total cost without contingency).

2.2.1 Bayway to Federal Square 138 kV Underground Line (K-1311)

The existing Bayway to Federal Square 138 kV underground line is 9.16 miles long and has an emergency rating of 350 MVA. The results of the T107 System Impact Study showed that during a single contingency outage ('BAYW_DRMS'), the Bayway to Federal Square 138 kV line overloaded to 101% of its emergency rating. As a result, the line needs to be upgraded to 205/399 MVA normal and emergency ratings to accommodate the T107 project.

The existing Bayway to Federal Square 138 kV underground transmission line was evaluated to determine the appropriate upgrades necessary to meet the T107 loading requirements. Ampacity calculations were performed by modeling the existing installation conditions for the existing circuit. The ampacity calculations were based on the known circuit parameters and typical PSE&G conditions to determine a baseline for the upgrades. Table 2-8 below outlines the existing Bayway to Federal 138 kV circuit parameters.

Table 2-8: Bayway to Federal Square 138 kV U/G Line – Existing Circuit Parameters

Circuit Parameter/Conditions	Value
Voltage	138kV
Cable Type	HPGF/HPFF
Conductor	2500/1250 kcmil copper (HPGF) 2000 kcmil copper (HPFF)
Insulation	600 mil/ 505 mil Kraft Paper
Pipe Diameter	8"
Depth of Cover at Worst Case	30'
Installation Conditions at Worst Case	Jack & Bore under Route 22 on-ramp
Native Soil Rho at Worst Case	1.0°C M/W
Ambient temperature at Worst Case	20°C
Load Factor	1
Max Operating Temperature	80°C/100°C

The ampacity calculations were based on the existing plan and profile drawings and the deepest point along the line. The Bayway to Federal Square 138 kV circuit passes under the Route 22 onramp via a jack and bore at approximately 30 feet deep. This depth was determined to be the worst case scenario for the Bayway to Federal 138 kV underground circuit.

Using the installation conditions described above, the necessary upgrades were developed to achieve the requested ratings shown in

[Table 2-9](#)
[Table 2-9](#) below.

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Table 2-9: Bayway to Federal Square 138 kV U/G Line - Required Cable Ratings

Rating Type	Value
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Normal Rating	205 MVA
	860A
Emergency Rating	399 MVA
	1670 A
Emergency Duration	4 hr

The *Cymcap* software was used to calculate the cable sizing for the ratings listed in at the 30 foot worst case installation scenario.

Based on the *Cymcap* cable calculations, the Bayway to Federal Square 138 kV underground circuit can be upgraded utilizing the existing HPGF and HPFF pipes. By converting the HPGF portion of the circuit to HPFF and reconductoring the entire circuit length with 3000 kcmil copper PPP insulated cable, the requested ratings can be attained. Although there are other upgrades that would satisfy the requested ratings, this option is the most logical and cost effective, as no additional civil construction would be required.

2.2.1.1 Cost Estimate and Design Assumptions

In addition to the general cost estimate assumptions listed in Section 2.2, the following specific assumptions apply to the design and cost estimate of the Bayway to Federal Square 138 kV underground line:

1. Assumed use of existing manhole system
2. Assumed conversion of HPGF to HPFF
3. Assumed use of existing termination structures
4. Assumed replacement of dielectric fluid for entire circuit length.
5. Direct costs for PSE&G were assumed to be \$1,500,000. The siting and permitting costs are assumed to be included in the PSE&G direct costs.

2.2.1.2 Cost Estimate

The cost estimate to upgrade the Bayway to Federal Square 138 kV line is shown in Table 2-10 below. The total cost for Bayway to Federal Square 138 kV line upgrade is estimated at \$54,989,800.

Table 2-10: Bayway to Federal Square 138 kV U/G Line Upgrade - Cost Estimate

Item	Material Cost	Labor Cost	Total
Civil Construction	\$659,000	\$2,506,000	\$3,165,000
Electrical Construction	\$27,726,000	\$3,842,000	\$31,568,000
Engineering & Construction Management		\$3,474,000	\$3,474,000
PSE&G Direct Costs		\$1,500,000	\$1,500,000
Contingency	\$11,354,000	\$3,928,800	\$15,282,800
Total without Contingency			\$39,707,000
Total with Contingency			\$54,989,800

2.2.1.3 Schedule

A construction schedule for the Bayway to Federal Square 138 kV underground circuit upgrade is shown in Table 2-11 below. It is important to note that based on current information available on the HPFF conductor, the assumed procurement lead time was 20 months. This procurement lead time is reflected in the duration estimated for the Materials Procurement phase of the project. For the basis of duration, it is

assumed that each month has an average of 22 working days per month. For the construction portion of the schedule, it is assumed the contractor will work eight hours per day and five days per week.

Table 2-11: Bayway to Federal Square 138 kV U/G Line Upgrade - Project Schedule

Project Phase	Start Date	Finish Date
Notice to Proceed	January 2012	January 2012
Permitting	January 2012	March 2012
Engineering Design	March 2012	April 2015
Materials Procurement	September 2012	January 2015
Construction	June 2014	April 2015
Total U/G Line Project	January 2012	April 2015

2.2.2 Athenia to Bergen 230 kV Underground Line

The Athenia to Bergen 230 kV underground line proposed¹ in the O66 Facilities Study Report is 9.7 miles long and has normal/emergency ratings of 305/524 MVA. The line loads up to 121% of its 524 MVA emergency rating for a line fault with failed breaker contingency outage ‘PS1’ (refer to the T107 System Impact Study for details). To alleviate the overload, the ratings of the proposed the Athenia to Bergen 230 kV underground line were increased to 370/635 MVA to accommodate the T107 interconnection as shown in [Table 2-12](#) below.

Table 2-12: Athenia to Bergen 230 kV U/G Line - Required Ratings

Parameter	MVA Rating	Ampacity	
		230kV	345kV
Normal Rating	370 MVA	929 A	620 A
Emergency Rating	635 MVA	1594 A	1063 A
Emergency Duration	4 hrs		

In order to determine the upgrade options needed to achieve the required ratings for the proposed Athenia to Bergen 230 kV underground transmission line, ampacity calculations were performed by modeling the currently proposed installation conditions. The ampacity calculations were based on existing installation conditions and typical PSE&G conditions to determine a baseline for the upgrade options. [Table 2-13](#) below outlines the currently proposed Athenia to Bergen 230 kV circuit parameters.

The worst case scenario established for the Athenia to Bergen circuit is based on a river crossing utilizing a horizontal directional drilling (HDD) method. This worst case scenario was developed based on the preliminary PSE&G circuit route which depicts the cable route crossing both the Hackensack and Passaic rivers.

Table 2-13: Athenia to Bergen 230 kV U/G Line – Proposed Circuit Parameters

Parameters/Conditions	Value
Depth of Cover at Worst Case	25'

¹ Per the PJM Generator Interconnection Request Queue #O66/V1-034 Bergen 230 kV Facilities Study Report

Installation Conditions at Worst Case	HDD Under River
Native Soil Rho at Worst Case	2.2°C M/W
Ambient temperature at Worst Case	20°C
Load Factor	1
Max Operating Temperature (HPFF)	80°C/100°C
Max Operating Temperature (XLPE)	90°C/105°C

Based on current drilling technologies, NOAA navigation charts for the rivers with depth soundings, and previous experience, it was determined that the worst case installation would be at a depth of approximately 25 feet. This depth is an approximation and may be also be governed by U.S. Army Corps of Engineers, as this is a navigable body of water. Due to the highly organic nature of the sediment that the river bed is comprised of, a higher thermal resistivity (rho) was also used for the worst case installation condition.

With the installation conditions described above, four options were evaluated for achieving the requested ratings listed in [Table 2-12](#) above. [Table 2-14](#) below shows the evaluated options and the results of the evaluation. The *Cymcap* software was used to calculate the cable sizing for the four evaluated options at the 25 foot worst case installation scenario.

Table 2-14: Athenia to Bergen 230 kV U/G Line – Upgrade Options

Option #	Option Description	Evaluation Result
1	230 kV Single HPFF Circuit	Does Not Meet the Ratings Requirements
2	345 kV Single HPFF Circuit	Does Not Meet the Ratings Requirements
3	230 kV Single XLPE Circuit	Meets the Ratings Requirements (Recommended Option)
4	345 kV Single XLPE Circuit	Meets the Ratings Requirement Requires Additional Terminal Work

The results of the *Cymcap* calculation based on the worst case scenario for the Athenia to Bergen U/G circuit showed that a single 5000kcmil XLPE cable per phase meets the requested ratings (Option 3). Option 3 provides a solution to the T107 ratings in a single cable per phase package rather than upgrading the proposed O66 installation. The other three options were dismissed due to rating inadequacies, cost, and engineering judgment.

2.2.2.1 Cost Estimate and Design Assumptions

In addition to the general cost estimate assumptions listed in section [2.22.2](#), the following specific assumptions apply to the design and cost estimate of the Athenia to Bergen 230 kV underground line:

1. Assumed 10% rock content.
2. Assumed two (2) river crossings via HDD based on PSE&G provided route.
3. Estimate based on concrete encased duct bank and manhole system.
4. Estimated duct bank and manhole system consists of four (4) eight-inch PVC conduits for the power cables (three plus one spare) and two (2) two-inch conduits for grounding and communications.
5. Direct costs for PSE&G were assumed to be \$3,000,000. The program management costs are assumed to be included in the PSE&G direct costs.
6. The Environmental & Resource Recovery, Licensing & Permitting and Corporate Properties costs are as stated in the O66 Facilities Study Report.

2.2.2.2 Cost Estimate

The cost estimate to for the singular solution 5000 kcmil XLPE cable in the Athenia to Bergen 230 kV circuit is shown in [Table 2-15](#) below. The total cost for Athenia to Bergen 230 kV underground circuit is estimated at \$124,597,500.

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Table 2-15: Athenia to Bergen 230 kV U/G Line Upgrade - Cost Estimate

Item	Material Cost	Labor Cost	Total
Civil Construction	\$9,895,000	\$34,697,000	\$44,592,000
Electrical Construction	\$21,671,000	\$4,612,000	\$26,283,000
Engineering & Construction management		\$7,087,500	\$7,087,500
Environmental & Resource Recovery		\$3,950,000	\$3,950,000
Licensing & Permitting		\$3,500,000	\$3,500,000
Corporate Properties	\$5,000,000		\$5,000,000
PSE&G Direct Costs		\$3,000,000	\$3,000,000
Contingency	\$12,626,400	\$18,558,600	\$31,185,000
Total without Contingency			\$93,412,500
Total with Contingency			\$124,597,500

2.2.2.3 Construction Schedule

Since the Athenia to Bergen 230 kV underground circuit proposed in this T107 Facilities Study Report would replace the circuit proposed in the O-66 facilities study, it was assumed that the original O-66 permit process will require minimal modifications for the revised Athenia to Bergen 230 kV underground circuit and was not accounted for in this Facilities Study.

The construction schedule for Athenia to Bergen 230 kV underground line upgrade is shown in [Table 2-16](#) below. The project schedule for the breakers at the Bergen Substation (11H, 12H & 20 H) and the breakers at the Athenia Substation (21H, 11H & 51H) are also included in the Athenia to Bergen 230 kV underground line construction schedule package.

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Table 2-16: Athenia to Bergen 230 kV U/G Line & Substation Upgrade - Project Schedule

Project Phase	Start Date	Finish Date
Notice to Proceed (UG Line)	January 2012	
Notice to Proceed (Substation)	March 2014	March 2014
Permitting	January 2012	February 2012
Engineering Design	February 2012	February 2015
Materials Procurement	June 2013	February 2015
Construction	September 2013	April 2015
Combined Project	January 2012	April 2015

2.3 OVERHEAD TRANSMISSION LINES

(The work described in this section is not required for interconnection of the T107 project except for section 2.3.2 Essex – Hudson 230 kV OH Line A-2227)

The following sections describe the cost estimate assumption, cost estimates and construction schedules for the Kearny to Marion 138 kV (circuit N1314) and Essex to Hudson 230 kV (circuit A2227) overhead transmission lines requiring upgrades due to the interconnection of T107.

The design and cost estimates for the two overhead transmission lines are based on the following general assumptions:

1. Cost estimates were based on 2011 dollars, no escalation or discount rates were included.
2. Costs adjusted to Newark, NJ city cost index.
3. No state taxes included.
4. Contingency is assumed to be 40% of total material and labor costs.
5. Direct costs for PSE&G are included at 20% of base cost (total cost without contingency). The PSE&G direct costs also include all siting and permitting costs.
6. No environmental costs included.
7. No real estate or land acquisition costs included.

2.3.1 Kearny to Marion 138 kV Overhead Line (N-1314)

The existing Kearny to Marion 138 kV overhead (O/H) line is 1.68 miles long and has an emergency rating of 482 MVA. The line loads to approximately 105% for an outage of a tower (contingency '27PS'). This overload can be alleviated by reconductoring and rebuilding the circuit with 1590 ACSS conductor. The reconducted line will accommodate the required 700/800 MVA normal/emergency ratings. In addition, the Kearny to Marion 138 kV line corridor is highly constrained and includes many railroad and roadway crossings.

2.3.1.1 Cost Estimate and Design Assumptions

The specific cost and design assumptions applied to the design and cost estimates for the reconductor and rebuild of the Kearny to Marion 138 kV O/H circuit are as follows:

1. Assumed structure replacement would be required for all existing structures.
2. Assumed the existing ROW is adequate for the new requirements.

3. No survey/geotechnical costs included.

2.3.1.2 Cost Estimate

The cost estimate to rebuild the Kearny to Marion 138 kV O/H line is shown in [Table 2-17](#) below. The total cost for Kearny to Marion 138 kV O/H circuit is estimated at \$21,800,000.

Table 2-17: Kearny to Marion 138 kV O/H Line Rebuild - Cost Estimate

Item	Material Cost	Labor Cost	Total
Removals	\$0	\$2,804,000	\$2,804,000
Foundations	\$1,035,000	\$3,105,000	\$4,140,000
Structures	\$1,713,000	\$3,140,000	\$4,853,000
Hardware	\$240,000	\$240,000	\$480,000
Conductor/Shield Wire	\$231,000	\$817,000	\$1,048,000
Engineering & Construction Management	\$0	\$300,000	\$300,000
PSE&G Direct Costs		\$2,725,000	\$2,725,000
Contingency	\$1,287,600	\$4,162,400	\$5,450,000
Total without Contingency			\$16,350,000
Total with Contingency			\$21,800,000

2.3.1.3 Schedule

The construction schedule for the Kearny to Marion 138 kV O/H line rebuild is shown in [Table 2-18](#).

Table 2-18: Kearny to Marion 138 kV Substation & O/H Line Rebuild - Project Schedule

Project Phase	Start Date	Finish Date
Notice to Proceed	January 2012	January 2012
Permitting	January 2012	December 2012
Engineering Design	August 2012	September 2013
Materials Procurement	December 2012	March 2014
Construction	July 2013	April 2014
Combined Project	January 2012	April 2014

2.3.2 **Essex to Hudson 230 kV Overhead Line (A-2227)**

The existing Essex to Hudson 230 kV overhead transmission line is 6.26 miles in length and has an emergency rating of 826 MVA. The line loads to 121% of its emergency rating for single tower contingency ('32PS'). The overload can be alleviated by reconductoring the circuit with 1590 ACSS with new ratings of 800/1050 MVA (normal/emergency ratings).

2.3.2.1 Cost Estimate and Design Assumptions

The specific design assumptions applied to the design and cost estimate of the Essex – Hudson 230 kV line upgrade are as follows:

1. Assumed structural modifications would be required on two thirds of the existing structures.
2. Assumed no new structures and no modified/replaced foundations would be required.
3. Assumed the existing ROW is adequate for the new requirements.
4. No survey/geotechnical costs included.
5. Assumes flat rate cost for structural reinforcements per structure type.

2.3.2.2 Cost Estimate

The cost estimate to rebuild the Essex to Hudson 230 kV O/H line is \$13,872,000 as shown in [Table 2-19](#) below.

Table 2-19: Essex to Hudson 230 kV O/H Line Upgrade - Cost Estimate

Item	Material Cost	Labor Cost	Total
Removals		\$298,000	\$298,000
Structure Modifications	\$934,000	\$2,800,000	\$3,734,000
Replacement Hardware	\$1,300,000	\$1,300,000	\$2,600,000
Replacement Conductor	\$348,000	\$1,190,000	\$1,538,000
Engineering & Construction Management		\$500,000	\$500,000
PSE&G Direct Costs		\$1,734,000	\$1,734,000
Contingency	\$1,032,800	\$2,435,200	\$3,468,000
Total without Contingency			\$10,404,000
Total with Contingency			\$13,872,000

2.3.2.3 Schedule

The construction schedule for the Essex to Hudson 230 kV line upgrade project is shown in [Table 2-20](#) and includes the Essex to Hudson 230 kV line end breaker 22H at the Essex substation is also included in the line upgrade schedule.

Table 2-20: Essex to Hudson 230 kV O/H Line & Substation Upgrade - Project Schedule

Project Phase	Start Date	Finish Date
Notice to Proceed	January 2012	January 2012
Permitting	January 2012	June 2012
Engineering Design	January 2012	July 2012
Materials Procurement	July 2012	March 2013
Construction	February 2013	July 2013
Total Combined Project	January 2012	July 2013

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3. SUMMARY

The interconnection of the 625 MW T107 project to the PSE&G Essex 230 substation requires upgrades to existing system facilities as identified in the T107 System Impact Study. The cost estimate and construction schedules of each of the facility upgrades are summarized in the following sections.

3.1 TOTAL COST SUMMARY

The allocated cost for each network upgrade and the total allocated cost for the T107 project is shown in Table 3-1.

Table 3-1: T107 Facilities Upgrade – Allocated Cost Estimates

Upgrade	Number	Total Estimate	Contingency	Estimate w/o Contingency	% Allocation	Total
Essex 230kV Three Breaker Bay Expansion less one breaker	N3301	\$6,847,680	\$1,264,800	\$5,582,880	1.0000	\$5,582,880
Essex Trans. #1	N2080	\$15,290,880	\$2,316,800	\$12,974,080	1.0000	\$12,974,080
Essex Bkr 3LM 138 kV	N1235	\$1,423,600	\$158,000	\$1,265,600	1.0000	\$1,265,600
Essex Bkr 1 PM 138 kV	N1233	\$1,423,600	\$158,000	\$1,265,600	1.0000	\$1,265,600
Essex Bkr 3PM 138 kV	N1232	\$1,423,600	\$158,000	\$1,265,600	1.0000	\$1,265,600
Essex Bkr 22H 230 kV	N1236	\$1,658,000	\$158,000	\$1,500,000	1.0000	\$1,500,000
Essex Bkr 4LM 138 kV	N1237	\$1,491,600	\$226,000	\$1,265,600	1.0000	\$1,265,600
Bergen Bkr 12H	N0984	\$1,658,000	\$158,000	\$1,500,000	0.7087	\$1,063,050
Athenia Bkr 21 H	N0985	\$1,658,000	\$158,000	\$1,500,000	0.5646	\$846,900
Athenia Bkr 11 H	N0986	\$1,658,000	\$158,000	\$1,500,000	0.9341	\$1,401,150
Athenia Bkr 51 H	N0987	\$1,658,000	\$158,000	\$1,500,000	0.9438	\$1,415,700
Essex-Hudson 230kV	N2079	\$13,872,000	\$3,468,000	\$10,404,000	1.0000	\$10,404,000
Total						\$40,250,160

3.2 PROJECT SCHEDULE SUMMARY

The T107 facility upgrades were divided into six different construction packages based on the expected execution of the project construction. The schedule for each of the construction packages is shown in [Table 3-2](#) below.

Based on the project start date of January 2012, the project completion date is estimated to be April 2015.

Table 3-2: T107 Facilities Upgrade - Project Schedules

Construction Schedule Package	Package Descriptions	Network Upgrades # Included in Package	Substation Upgrades Included in Package	Start Date	Finish Date
1	Essex 230 kV Substation Package: Essex 230kV 3-breaker bay expansion Essex 230kV & 138 kV breakers Essex 230/138kV Transformers #1	N2080, N1602, N1407, N1408, N1235, N1233, N1232 & N1236	Essex 138 kV breakers, 4LM, 3LM, 1PM & 3PM and Essex 230kV 3-breaker Bay Expansion, Essex 230kV breaker 22H replacement and 2-Essex 230/138kV transformers	November 2012	April 2015
2	ECRR 138kV Substation	N1405 & N1406	ECRR 138kV breakers 901 & 902	April 2014	April 2015
3	Athenia-Bergen 230kV Underground Line	N2135, N1403, N0984, N1404, N0985, N0986 & N0987	Bergen 230 kV breakers 11H, 12H & 20H and Athenia 230kV breakers 21H, 11H & 51H	January 2012	April 2015
4	Bayway – Federal Square 138 kV Underground Line	N2136	None	January 2012	April 2015
5	Kearny-Marion 138kV Overhead Line	N2078, N1425, N1426	Marion 138kV breakers 8PM& 5PM	January 2012	April 2014
6	Essex-Hudson 230kV Overhead Line	N2079	None	January 2012	July 2013
Overall T107 Project Schedule				January 2012	April 2015

3.3 FERC REQUIRED COST BREAKDOWN

Direct Labor \$19,601,940
 Direct Material \$18,704,901
 Indirect Labor \$1,943,319
 Total \$40,250,160

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