

Generation Interconnection

This analysis was completed to assess the reliability impact for a new generator interconnecting to the PJM system as a capacity resource.

Network Impacts -750 MW Injection into the Linden 230kV substation

Revised Posting

PJM Generator Interconnection Request Queue A4 Linden 230 kV Impact Study Report

DMS # 110461 v2

September 2000

Linden Impact Study

General

PSEG initially proposed installation of a 750 MW combined cycle plant, in addition to the existing generation, on the Linden Generating Station property. As position C1 in the queue PSEG expanded the project to be two identical combined cycle projects of 593 MW, with the additional output connected to the 138 kV bus replacing Linden units #1, #2 and #3. The proposed project consists of two combined cycle generation blocks each comprised of two GE Frame 7 combustion turbines which will exhaust into two Heat Recovery Steam Generators (HRSG) that will drive one steam turbine generator. The project has an in service date of the year 2003 and will be located in Linden, Union County, New Jersey.

This report will reflect analysis and will define system requirements for the interconnection request of 750 MW made by PSEG and listed as queue position A4.

The intent of the impact study is to determine cost and construction time estimates of system reinforcements required to facilitate the addition of the new generating plant to the PJM system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the PJM system.

Direct Connection

Three combustion turbines and one steam turbine will be interconnected to the transmission system via a 230 kV overhead transmission circuit from the generation facility switching station to the Linden 230 kV switching station. The new circuit will have a summer normal rating of 850 MVA. To accommodate the new line in the Linden 230 kV substation, one new line terminal position, consisting of two new 230 kV circuit breakers, with a short circuit rating of at least 63kA, and associated 3000 amp line disconnect switches will be constructed. An additional 230 kV breaker will be added to isolate the 2253 line from the bus section. The attached diagram, Figure #1, shows the interconnection of the generating plant to the Linden 230 kV substation.

It is estimated that the 230 kV overhead transmission circuit will cost \$1 million and the additions in the Linden 230 kV substation will cost \$4.7 million and will take approximately 24 months to construct. Total direct connection costs are \$5.7 million.

The new generating plant 230 kV switching station is not included in the cost estimate.

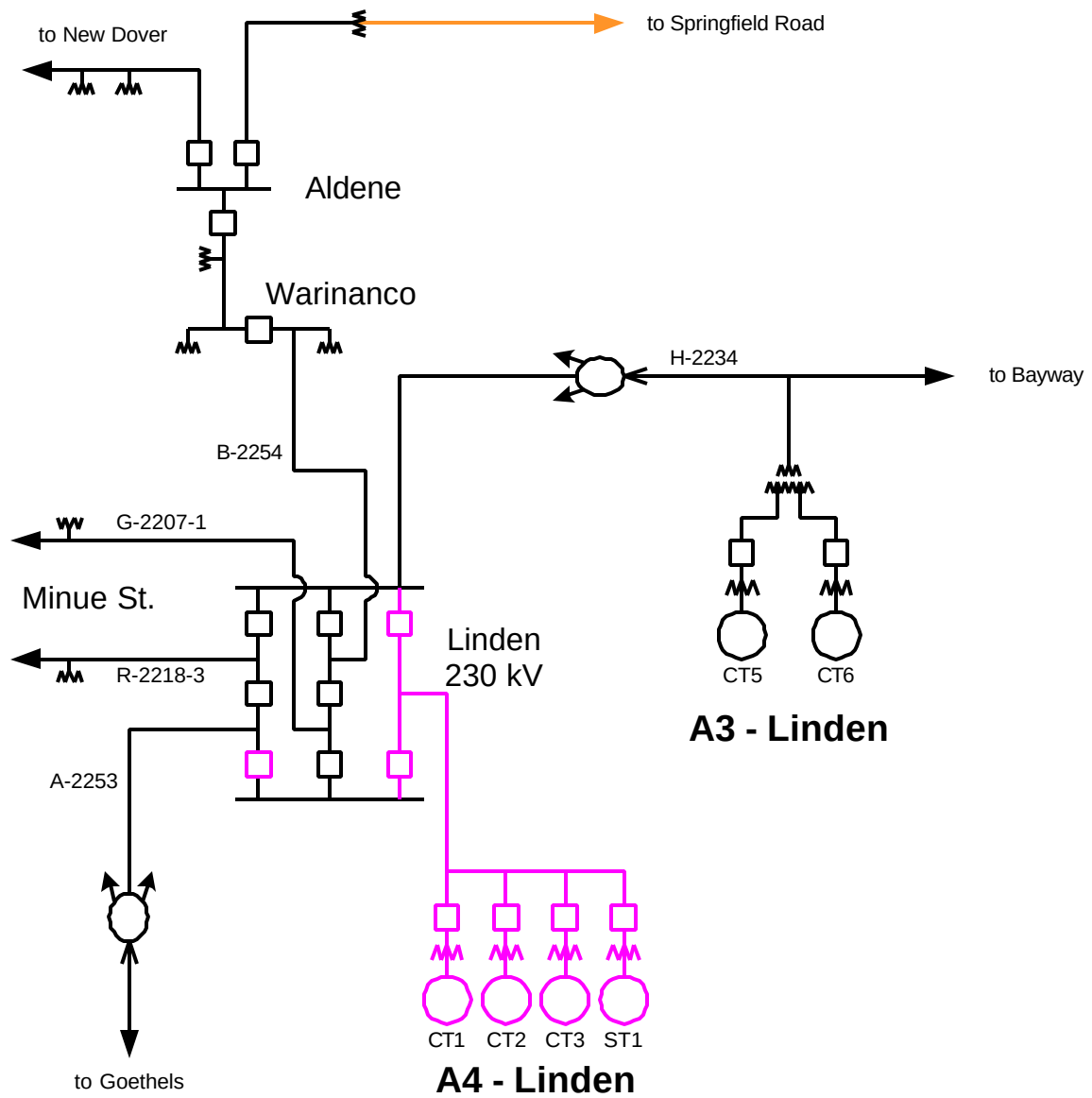


Figure 1

Network Impacts

Potential network impacts for the injection of 750 MW at the Linden 230 kV substation were evaluated for compliance with reliability criteria. The results are summarized below.

Normal System

- The Linden – Goethels PAR (Phase Angle Regulator) exceeds the existing angular range by 5°.

Single Contingency (MAAC Criteria IIA)

- No problems identified.

Second Contingency (MAAC Criteria IIB)

- No problems identified.

Multiple Facility Contingency (MAAC Criteria IIC)

- The Linden – Warinanco 230 kV circuit is 109% overloaded due to the 230 kV DCTL (Double Circuit Tower Line) contingency outage of the Linden – Deans and the Linden – Sewaren 230 kV circuits.
- The Sewaren – Woodbridge “V” 138 kV circuit is 107% overloaded due to a fault on the Deans – Brunswick 230 kV circuit with a stuck breaker at Deans resulting in the outage of the Deans 500/230 kV transformer #3.

Generator Deliverability

- No problems identified.

Stability (MAAC Criteria IV)

- Stability analysis was performed at light load conditions and for maximum summer generator output of 764 MW.

No identified problems.

See attachment #1 for the fault cases evaluated.

The range of contingencies evaluated was limited to that necessary to demonstrate compliance with MAAC Reliability Criteria IV.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at higher levels of generator output over a range of load levels would disclose unforeseen stability problems. The MAAC yearly reliability analysis to be performed to test all system changes will include this evaluation. Any problems uncovered will need to be resolved.

CETO/CETL (MAAC Criteria III / VIIB)

- No problems identified.

Short Circuit Analysis

- The addition of the Linden 750 MW project causes three 230 kV breakers to exceed their interrupting capability. The three circuit breakers are at Deans (BS1-5, BS1-7, and BS1-9 @ 106%).

System Reinforcements

- The Linden-Goethels PAR (Phase Angle Regulator) concern described above will be alleviated by reconductoring the Kearny–Turnpike segments of the Kearny-Roseland 138 kV circuits resulting in increased ratings for the entire path from Kearny to Roseland to 249 MVA normal and 308 MVA emergency. This increased line capacity provides the ability to move more power from the Linden substation on the Linden to Bayway PAR. It also provides some flexibility on the PSE&G to Con-Ed ties so that the 1000 MW “out” wheel is delivered as 900 MW “out” at Hudson and 100 MW “out” at Linden. Previous to the Kearny–Turnpike 138 kV line reconductor, the 1000 MW “out” wheel was limited to the Hudson PARs with 0 MWs “out” at Linden to maintain the 1000 MW contract agreement. This line reconductor provides additional PAR flexibility such that the Linden generator no longer exceeds the Linden–Goethels PAR angular range. It is estimated that the reconductoring cost will be \$500,000 and will take 2 years to complete.
- The overload on the Linden- Warinanco 230 kV circuit will be alleviated by replacing the wavetrapp at the Linden terminal of the line. This will increase the circuit rating to 734 MVA normal and 873 MVA emergency. The wavetrapp replacement is estimated to cost \$100,000 and take 1 year to complete.
- The overload on the Sewaren-Woodbridge "V" 138 kV circuit will be alleviated by replacing the wavetrapp at the Sewaren terminal of the line. This will increase the circuit ratings to 249 MVA normal and 308 MVA emergency. The wavetrapp replacement is estimated to cost \$100,000 and take 1 year to complete.
- The three breakers that exceed their short circuit interrupting capability can be upgraded by adding grading capacitors to increase their interrupting capability to 43 kA. It is estimated the upgrade will cost \$75,000 per breaker. The cost to upgrade all three breakers is \$225,000 and will take 1 year to complete.

Cost Allocation

The cost of \$1 million for the 230 kV overhead circuit for connection to the 230 kV substation and the cost of \$4.7 million to add three 230 kV circuit breakers and termination for the overhead circuit are direct connection costs. The \$5.7 million total is 100% attributable to and are the responsibility of the Linden A4 project.

Since the Linden project initiates the need for the four network problems described above the project has 100% responsibility for the cost of each of the upgrades. The total network upgrade costs for the project are estimated to be \$0.925 million.

The total cost estimated to connect the Linden A4 project is \$6.625 million.

Attachment #1

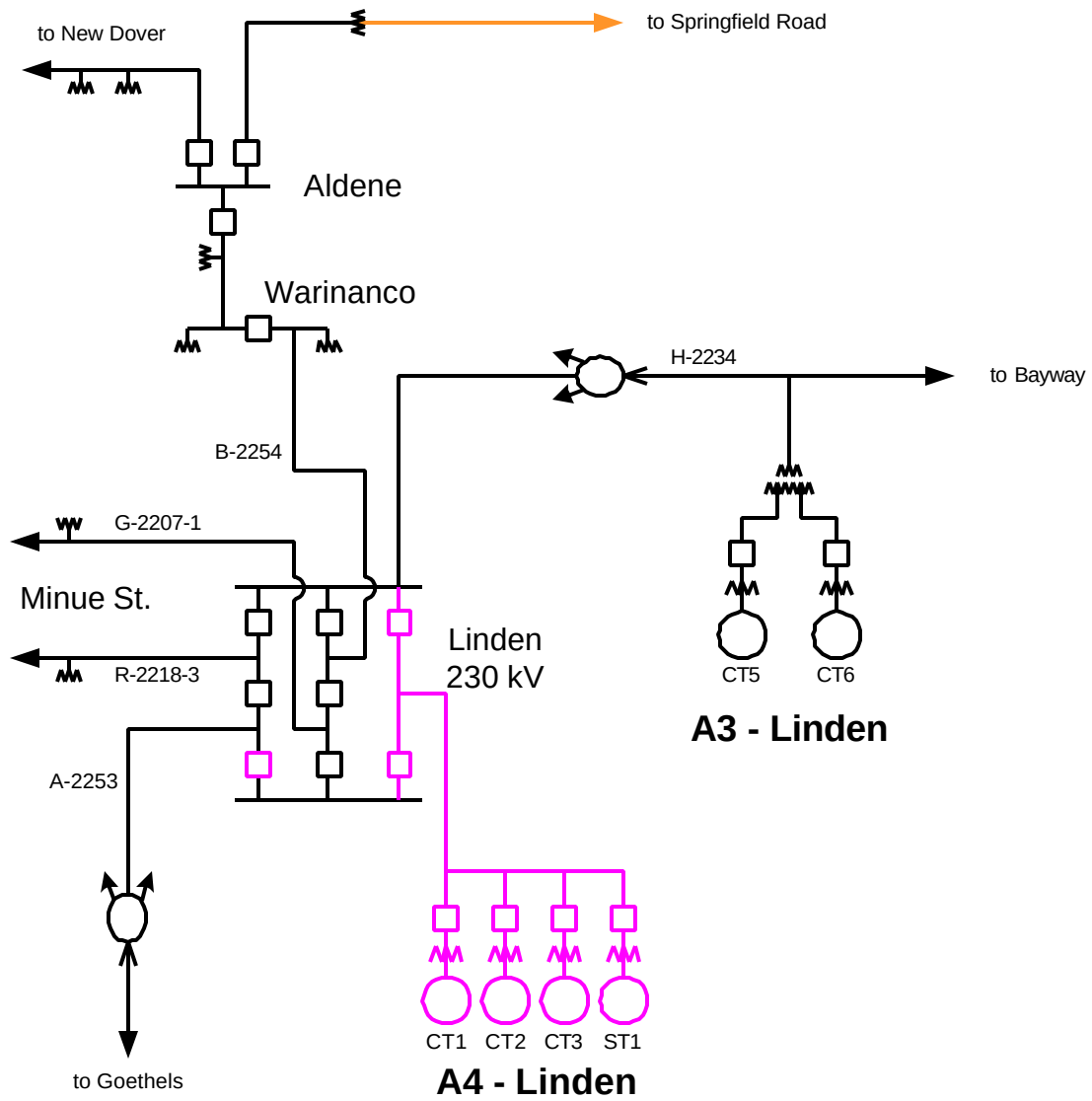
PSEG Global (Linden Project A4) 2004 Light Load Stability Faults

Breaker Clearing Times (cycles)

Station	Primary	Stuck Breaker Timer (total)
All 230 kV	5	17

ALL FAULTS ARE STABLE

a4-1a	3ph @ Linden 230 kV on Linden – Goethals 230 kV
a4-1b	3ph @ Linden 230 kV on Linden – Warinanco 230 kV
a4-1c	3ph @ Linden 230 kV on Linden – Deans 230 kV
a4-1d	3ph @ Linden 230 kV on Linden – Sewaren 230 kV
a4-1e	3ph @ Linden 230 kV on Linden – Bayway 230 kV
a4-1f	slg @ Linden 230 kV on Linden – Goethals 230 kV, stuck at Linden (L/O Linden-Sewaren)
a4-1g	slg @ Linden 230 kV on Linden – Warinanco 230 kV, stuck at Linden (L/O Linden-Deans)
a4-1h	slg @ Linden 230 kV on Linden – Deans 230 kV, stuck at Linden (L/O Linden-Warinanco)
a4-1i	slg @ Linden 230 kV on Linden – Sewaren 230 kV, stuck at Linden (L/O Linden-Goethals)
a4-1j	slg @ Linden 230 kV on Linden – Bayway 230 kV, stuck at Linden (L/O Linden-Sewaren)



Original Posting

***PJM Generator Interconnection Request
Queue #A4/C1
Linden 230 and 138 kV
Impact Study Report***

June 2000DMS # 110461Linden
Impact Study

General

PSEG initially proposed installation of a 750 MW combined cycle plant, in addition to the existing generation, on the Linden Generating Station property. As position C1 in the queue PSEG expanded the project to be two identical combined cycle projects of 593 MW, with the additional output connected to the 138 kV bus replacing and utilizing the capacity interconnection rights of Linden units #1, #2 and #3. The proposed project consists of two combined cycle generation blocks each comprised of two GE Frame 7 combustion turbines which will exhaust into two Heat Recovery Steam Generators (HRSG) that will drive one steam turbine generator. The project has an in service date of the year 2003 and will be located in Linden, Union County, New Jersey.

This report will reflect analysis for the entire project and will define system requirements for the interconnection requests made by PSEG and listed as queue positions A4 and C1.

The intent of the impact study is to determine cost and construction time estimates of system reinforcements required to facilitate the addition of the new generating plant to the PJM system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the PJM system.

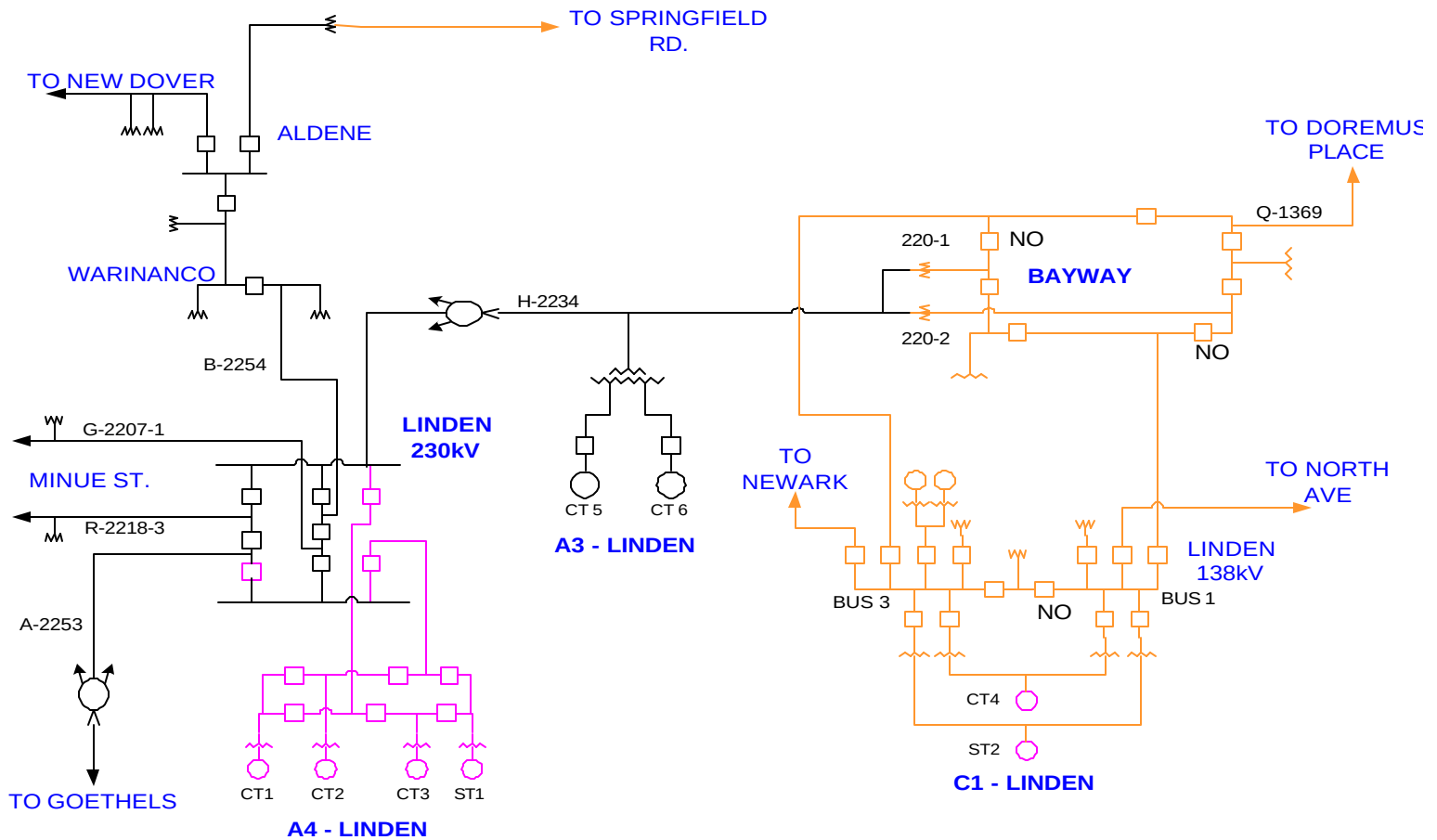
Direct Connection

Three combustion turbines and one steam turbine will be interconnected to the transmission system via a 230 kV double circuit tower line from the generation facility switching station to the Linden 230 kV switching station. Each new circuit will have a summer normal rating of 850 MVA. To accommodate the two new lines in the Linden 230 kV substation two new line terminal positions, consisting of new 230 kV circuit breakers, with a short circuit rating of at least 63kA, and associated 3000 amp line disconnect switches will be constructed. An additional 230 kV breaker will be added to isolate the 2253 line from the bus section. One combustion turbine and one steam turbine will be connected to the 138 kV substation via existing transformers 1A, 1B, 2A, and 2B, replacing connections from existing generating units #1 and #2. The attached diagram, Figure #1, shows the interconnection of the generating plant to the two busses at Linden substation.

It is estimated that the double circuit tower line will cost \$1.6 million and the additions in the Linden 230 kV substation will cost \$4.7 million and will take approximately 24 months to construct. Total direct connection costs are \$6.3 million.

The new generating plant 230 kV and 138 kV switching stations are not included in the cost estimate.

Figure #1



Network Impacts

Potential network impacts for the injection of 750 MW at the Linden 230 kV substation and 436 MW replacement at the Linden 138 kV substation were evaluated for compliance with reliability criteria. The results are summarized below.

Normal System

- The Linden – Goethels PAR (Phase Angle Regulator) exceeds the existing angular range by 5°.

Single Contingency (MAAC Criteria IIA)

- No problems identified.

Second Contingency (MAAC Criteria IIB)

- No problems identified.

Multiple Facility Contingency (MAAC Criteria IIC)

- The Linden – Warinanco 230 kV circuit is 109% overloaded due to the 230 kV DCTL (Double Circuit Tower Line) contingency outage of the Linden – Deans and the Linden – Sewaren 230 kV circuits.
- The Sewaren – Woodbridge “V” 138 kV circuit is 107% overloaded due to a fault on the Deans – Brunswick 230 kV circuit with a stuck breaker at Deans resulting in the outage of the Deans 500/230 kV transformer #3.

Generator Deliverability

- No problems identified.

Stability (MAAC Criteria IV)

- Stability analysis was performed at light load conditions and for maximum summer generator output of 1186 MW.

No identified problems.

See attachment #1 for the fault cases evaluated.

The range of contingencies evaluated was limited to that necessary to demonstrate compliance with MAAC Reliability Criteria IV.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at higher levels of generator output over a range of load levels would disclose unforeseen stability problems. The MAAC yearly reliability analysis to be performed to test all system changes will include this evaluation. Any problems uncovered will need to be resolved.

CETO/CETL (MAAC Criteria III / VIIB)

- No problems identified.

Short Circuit Analysis

- The addition of the Linden 750 MW project causes four 230 kV breakers to exceed their interrupting capability. One of these breakers is at Linden (BS5-6 @ 101.2%). The other three circuit breakers are at Deans (BS1-5, BS1-7, and BS1-9 @ 107%).

System Reinforcements

- The Linden-Goethels PAR (Phase Angle Regulator) concern described above will be alleviated by reconductoring the Kearny–Turnpike segments of the Kearny-Roseland 138 kV circuits resulting in increased ratings for each entire path from Kearny to Roseland to 249 MVA normal and 308 MVA emergency. This increased line capacity provides the ability to move more power from the Linden substation on the Linden to Bayway PAR. It also provides some flexibility on the PSE&G to Con-Ed ties so that the 1000 MW “out” wheel is delivered as 900 MW “out” at Hudson and 100 MW “out” at Linden. Previous to the Kearny–Turnpike 138 kV line reconductor, the 1000 MW “out” wheel was limited to the Hudson PARs with 0 MWs “out” at Linden to maintain the 1000 MW contract agreement. This line reconductor provides additional PAR flexibility such that the Linden generator no longer exceeds the Linden–Goethels PAR angular range. It is estimated that the reconductoring cost will be \$0.5 million and will take 2 years to complete.
- The overload on the Linden-Warinanco 230 kV circuit will be alleviated by replacing the wavetrapp at the Linden terminal of the line. This will increase the circuit rating to 734 MVA normal and 873 MVA emergency. The wavetrapp replacement is estimated to cost \$0.1 million and take 1 year to complete.
- The overload on the Sewaren-Woodbridge "V" 138 kV circuit will be alleviated by replacing the wavetrapp at the Sewaren terminal of the line. This will increase the circuit ratings to 249 MVA normal and 308 MVA emergency. The wavetrapp replacement is estimated to cost \$0.1 million and take 1 year to complete.
- The four breakers that exceed their short circuit interrupting capability can be upgraded by adding grading capacitors to increase their interrupting capability to 43 kA. It is estimated the upgrade will cost \$75,000 per breaker. The cost to upgrade all four breakers is \$300,000 and will take 1 year to complete.

Cost Allocation

The cost of \$1.6 million for the double circuit tower line for connection to the 230 kV substation and the cost of \$4.7 million to add three 230 kV circuit breakers and terminations for the double circuit lines are direct connection costs. The \$6.3 million total is 100% attributable to and are the responsibility of the Linden A4/C1 project.

Since the Linden project initiates the need for the four network problems described above the project has 100% responsibility for the cost of each of the upgrades. The total network upgrade costs for the project are estimated to be \$1 million.

The total cost estimated to connect the Linden A4/C1 project is \$7.3 million.

Attachment #1

Linden 230 kV Project A4 Linden 138 kV Project C1 2004 Light Load Stability Faults

Breaker Clearing Times (cycles)

Station	Primary	Stuck Breaker Timer (total)
All 230 kV	5.5	17
All 138 kV	6	18

ALL FAULTS ARE STABLE

- a4-1a 3ph @ Linden 230 kV on Linden – Goethels 230 kV
- a4-1b 3ph @ Linden 230 kV on Linden – Warinanco 230 kV
- a4-1c 3ph @ Linden 230 kV on Linden – Minue Street G 230 kV
- a4-1d 3ph @ Linden 230 kV on Linden – Minue Street R 230 kV
- a4-1e 3ph @ Linden 230 kV on Linden – Bayway 230 kV
- a4-1f slg @ Linden 230 kV on Linden – Goethels 230 kV, stuck at Linden (L/O Linden-Minue St. R)
- a4-1g slg @ Linden 230 kV on Linden – Warinanco 230 kV, stuck at Linden (L/O Linden-Minue St. G)
- a4-1h slg @ Linden 230 kV on Linden – Minue Street G 230 kV, stuck at Linden (L/O Linden-Warinanco)
- a4-1i slg @ Linden 230 kV on Linden – Minue Street R 230 kV, stuck at Linden (L/O Linden-Goethels)
- a4-1j slg @ Linden 230 kV on Linden – Bayway 230 kV, stuck at Linden (L/O Linden north bus)

- a4-2a 3ph @ Linden 1 138 kV on Linden 1 – Bayway 138 kV
- a4-2b 3ph @ Linden 1 138 kV on Linden 1 – North Avenue 138 kV
- a4-2c slg @ Linden 1 138 kV on Linden 1 – Bayway 138 kV, stuck at Linden 1 (L/O Linden 1 bus)
- a4-2d slg @ Linden 1 138 kV on Linden 1 – North Avenue 138 kV, stuck at Linden 1 (L/O Linden 1 bus)

- a4-3a 3ph @ Linden 3 138 kV on Linden 3 – Bayway 138 kV
- a4-3b 3ph @ Linden 3 138 kV on Linden 3 – Newark 138 kV
- a4-3c slg @ Linden 3 138 kV on Linden 3 – Bayway 138 kV, stuck at Linden 3 (L/O Linden 3 bus)
- a4-3d slg @ Linden 3 138 kV on Linden 3 – Newark 138 kV, stuck at Linden 3 (L/O Linden 3 bus)

- a4-4a 3ph @ Bayway 138 kV on Bayway – Linden 3 138 kV
- a4-4b 3ph @ Bayway 138 kV on Bayway – Linden 1 138 kV
- a4-4c 3ph @ Bayway 138 kV on Bayway – Doremus Place 138 kV
- a4-4d 3ph @ Bayway 138 kV on Bayway 230/138 kV #2
- a4-4e slg @ Bayway 138 kV on Bayway – Linden 3 138 kV, stuck at Bayway (L/O Bayway-Doremus Place)
- a4-4f slg @ Bayway 138 kV on Bayway – Linden 1 138 kV, stuck at Bayway (L/O Bayway south bus)
- a4-4g slg @ Bayway 138 kV on Bayway – Doremus Place 138 kV, stuck at Bayway (L/O Bayway-Linden 3)
- a4-4h slg @ Bayway 138 kV on Bayway 230/138 kV #1, stuck at Bayway (L/O Bayway south bus)

- a4-5a 3ph bus fault @ Linden 230 kV bus 1
- a4-5b 3ph bus fault @ Linden 1 138 kV
- a4-5c 3ph bus fault @ Linden 3 138 kV
- a4-5d 3ph bus fault @ Newark 138 kV
- a4-5e 3ph @ Linden ST1
- a4-5f 3ph @ Linden ST2

