PJM Generator Interconnection
T168 Four Rivers 230-kV (1010 MWC)
Feasibility Study

April 2008
DMS #479485 (PJM.com Version)

Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, §36.2, as well as the Feasibility Study Agreement between Interconnection Customer (IC) and PJM Interconnection, LLC (PJM) (Transmission Provider).

Preface

The intent of the feasibility study is to determine a plan, with preliminary cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications for the appropriate transmission owner.

In some instances an interconnection customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

At the request of the IC, this queue project, T168, was studied with two different interconnection options. For the first option, T168 was studied as a 1010MW injection at the Four Rivers 230 kV substation. For the second option, T168 was studied as a 1010MW injection at the Elmont 500 kV substation. The following study results list each option as an independent study.

Summary

	230-kV	500-kV
Attachment Facilities:	$0.50M & 1.5yrs.	$0.65M & 2yrs.
Direct Connection Network Upgrades:	$0.55M & 1.5yrs.	$30M & 5yrs.
Non-Direct Connection Network Upgrades:	$30.72M & 5yrs.	$1.2M & 1yr.
Contribution to Existing Upgrades:	$342M & 10 yrs.[1]	$337M & 10 yrs.[1]

[1] Cost allocation will be determined in the System Impact Study.

OPTION: 230-kV

The Queue Project #T168 was studied as a 1010MW injection at the Four Rivers 230-kV substation in the Dominion area. Project #T168 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

Network Impacts

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

1) (DOM) The 6FRRIVER-6HANOVER 230kV line loads from 72.5% to 198.8% (DC power flow) of its emergency rating (797MVA) for the single line contingency outage (LN 256). This project contributes approximately 1006.4MW to cause this thermal violation.

2) (DOM) The 6HANOVER-6ELMONT 230kV line loads from 66.6% to 192.9% (DC power flow) of its emergency rating (797MVA) for the single line contingency outage (LN 256). This project contributes approximately 1006.4MW to cause this thermal violation.

3) (DOM) The 6MINE RD-6FREDBRG 230kV line loads from 51.8% to 178.1% (DC power flow) of its emergency rating (797MVA) for the single line contingency outage (LN 2032). This project contributes approximately 1006.4MW to cause this thermal violation.

4) (DOM) The 6STJOHN-6MINE RD 230kV line loads from 51.4% to 157.6% (DC power flow) of its emergency rating (948MVA) for the single line contingency outage (LN 2032). This project contributes approximately 1006.4MW to cause this thermal violation.

5) (DOM) The 3FRRIVER-3HANOVER 115kV line loads from 98.1% to 128.8% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 2032). This project contributes approximately 61.1MW to cause this thermal violation.

6) (DOM) The 6FRRIVER-6HANOVER 230kV line loads from 54.4% to 155.5% (DC power flow) of its normal rating (797MVA) for non-contingency condition. This project contributes approximately 806.0MW to cause this thermal violation.

7) (DOM) The 6FREDBRG-3FREDBRG 230/115kV transformer loads from 85.47% (DC power flow) to 155.14% of its emergency rating (213MVA) for the single line contingency outage (LN 2032). This project contributes approximately 148.2MW to cause this thermal violation.

8) (DOM) The 6HANOVER-6ELMONT 230kV line loads from 48.5% to 149.6% (DC power flow) of its normal rating (797MVA) for non-contingency condition. This project contributes approximately 806.0MW to cause this thermal violation.

9) (DOM) The 6CRANES-6STAFORD 230kV line loads from 76.5% to 165.0% (DC power flow) of its emergency rating (722MVA) for the single line contingency outage (LN 2032). This project contributes approximately 638.8MW to cause this thermal violation.

10) (DOM) The 3HANOVER-3ELMONT 115kV line loads from 87.3% to 118.0% (DC power flow) of its emergency rating (199MVA) for the single line contingency outage (LN 2032). This project contributes approximately 61.1MW to cause this thermal violation.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

None.

Short Circuit

11) There are four (4) breaker interrupting capabilities with more than 100% as a result of T168 (230 kV Option). They are as follow:

Bus	Breaker No.
Elmont 230 kV	283T2032
Four Rivers 230 kV	2032T2067
Four Rivers 230 kV	2044T2067
Four Rivers 230 kV	256T2044

These results are subject to change due to changing system conditions.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

12) (DOM) The 6FREDBRG-6CRANES 230kV line loads from 102.15% to 202.44% (DC power flow) of its emergency rating (637MVA) for the single line contingency outage (LN 2032). This project contributes approximately 638.8MW to the thermal violation.

13) (BGE/PPL) The CONASTON-OTTERCRK 230kV line loads from 99.38% to 104.96% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 35.0MW to cause this thermal violation.

14) (BGE/PPL) The GRACETON-MANOR 230kV line loads from 125.48% to 131.62% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 32.6MW to the thermal violation.

15) (APS) The 01KEMPTN-N-NWEST 500kV line loads from 206.19% to 211.11% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (HIRDG_BURTVL). This project contributes approximately 142.7MW to the thermal violation.

Stability Analysis

(Results of the dynamic studies should be inserted here)

To be determined at the System Impact Study.

Dominion Analysis

Dominion assessed the impact on the Dominion Transmission System that the proposed 1010 MW injection of new generation capacity would have at the Four Rivers 230 kV Substation. The system was assessed using the Summer 2012 RTEP case provided to Dominion by PJM for this analysis. This analysis did include the impacts that higher order queue generators may have on the study results, specifically those generators located on the Dominion Transmission System which have a signed a PJM ISA or IISA and their associated network upgrades were also modeled. The following higher order queue projects were modeled in the PJM Summer 2012 case; P16, P27, Q69, Q71, R17, R63, S86-S96 and T10. When performing a generation analysis Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions) and import/export system conditions. Dominion Criteria consider a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import /export studies Dominion considers a transmission facility overloaded if it exceed 100% of its emergency rating. A full listing of Dominion's Planning Criteria and interconnection requirements can be found in the Company's Facility Connection Requirements which are publicly available at http://www.dom.com/about/elec-transmission/pdf/Facility_Connection_Requirements.pdf

As part of its generation impact analysis Dominion routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the T168 evaluation three different assessments were conducted.

1) The first being when local generation including the proposed T168 Facility is operated at their maximum capability. The result of this study

is indicating significant system deficiencies and is shown below in Table A.

2) The second being a stressed system condition, specifically when the largest generator in the area is unavailable. The proposed T168 generator is located on the 230 kV system between Richmond and Northern Virginia load areas. Therefore, the impact of T168 was studied under stressed system conditions where the most critical generating unit located on the 230 kV system in this load area is unavailable. Therefore, Possum Point Unit #5 was outaged to create this critical system condition. The result of this study is shown below in Table B.

3) The third being import and export conditions into and out of the Dominion System. Any new facility that is interconnected with the Dominion System should not significantly decrement FCITC (First Contingency Incremental Transfer Capability) between utilities. The results of these studies can be found in Tables C and D.

Table A
Summer 2012 Pmax System Conditions (Local Generators at Pmax)

Overloaded Element	Contingency Conditions	Pmax + T168
Four Rivers - Fredericksburg	1	194%
Four Rivers - Elmont	40+	194%
Fredericksburg – Cranes Corner	1	97%
Ladysmith Ct-Ladysmith	1	106%
Ladysmith 500-230 kV Tx	1	119%

Note: Note: For this study condition generation at Four Rivers was scaled to its maximum value (Pmax) and generation was proportionally reduced throughout the PJM System.

Table B
Summer 2012 Stressed System Conditions (No Possum Point Unit #5)

Overloaded Element	Contingency Conditions	Base Case + T168
Four Rivers - Fredericksburg	1	201%
Four Rivers - Elmont	40+	201%
Fredericksburg – Cranes Corner	1	111%
Ladysmith Ct-Ladysmith	1	106%
Ladysmith 500-230 kV Tx	1	119%

Note: Note: For this stress system condition Possum Point Unit #5 was removed from service and generation was increased within the Dominion System proportionally to make-up for the reduced generation.

The results of these studies indicate that approximately 43 miles of 230 kV lines are overloaded. Specifically the following 230 kV lines are overloaded.

a. Line # 256 (Four Rivers - Fredericksburg) 34 miles
b. Line # 2032 (Four Rivers - Elmont) 9 miles

Dominion's Planning Criteria also indicates a need to have approximately 2000 MW of import and export capability. The results of import and export studies are indicating that the proposed generation facility will no negatively impact Dominion's export or import capability.

Table C

Import Study Results			
Area	**Summer 2012**	**Summer 2012 with T168**	**Limiting Element**
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Table D

Export Study Results			
Area	**Summer 2012**	**Summer 2012 with T168**	**Limiting Element**
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Non-Direct Connection Network Upgrades

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

The estimated cost to replace the four over-duty 230 kV breakers (item #11 above) is $720,000 and will take about 8 weeks to complete. The equipment order time will take about 6 to 8 months.

As noted earlier the study results are indicating that approximately 43 miles of 230 kV lines are overloaded. Specifically the following 230 kV lines are overloaded.

a. Line # 256 (Four Rivers - Fredericksburg) 34 miles
b. Line # 2032 (Four Rivers - Elmont) 9 miles

The solution to resolve this overload would be to rebuild 115 kV Line #73 (Four Rivers-Elmont) as a double circuit 230 kV line and convert Line #73 to a 230 kV Line as part of this project. Line #73 and Line #2032 are physically located in the same right-of-way and there is enough room in this right-of-way to accommodate all three lines. A 230-115 kV transformer would also need to be installed at Four Rivers Substation. This solution is estimated to cost approximately $ 30 million dollars assuming no right-of-way needs to be acquired. This cost includes the

cost of converting equipment at Hanover Substation from 115 kV to 230 kV. This total upgrade is estimated to take 4-5 years to complete assuming standard SCC permitting times.

The proposed solution would resolve all the projected overloads identified in the Dominion and PJM Analysis as they relate to Dominion Transmission Facilities. Exact engineering cost and construction details will be developed as part of the Facilities Study.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

This addresses item #12 from the previously identified overloads listed above: The section of 230 kV line located between Fredericksburg and Cranes Corner Substation needs to be re-conductored to mitigate the overload condition. The cost of upgrading this 5 mile line is $2.2-$4.9M and is expected to take 0.5 years to complete.

This reinforcement addresses item #13 from the multiple facility contingency overloads listed above: The BG&E portion of the Conastone to Otter Creek line can be upgraded by reconductoring with 1,590 kcm ACSR from Gorsuch Mills to the Pennsylvania State Line (change of ownership to PPL). The length of this line section is 1.7 miles and its towers can be reinforced instead of replaced. The estimated cost and duration is $0.7M and 3 years. The PPL portion of the line can be upgraded by reconductoring approximately 17.2 miles with new 795 kcmil 30/19 ACSS. No terminal equipment upgrade is required at Otter Creek, it is currently built with 2000 amp rating equipment. The estimated cost of this upgrade is $8.5 million and the estimated construction time is 3 years.

This addresses item #14 from the previously identified overloads listed above: The BGE reinforcement is to reconductor with 1,590 kcm ACSR from Graceton to PA line (transfer of ownership to PPL) at an estimated cost and duration of $1.0M and 3 yrs. The length of this line section is 1.8 miles and its towers can be reinforced instead of replaced. The PPL reinforcement is to recondcutor with 1590 kcmil ACSR conductors (1 per phase). This rebuild will require new custom embedded steel poles to accommodate a larger conductor size. The rebuild will be 14.4 miles long and will travel the existing right of way. The estimated cost for this upgrade including substation terminal equipment cost is $31M.

This addresses item #15 from the previously identified overloads listed above: Kemptown to North Northwest 500 kV reinforcement requires two single circuit lines at an estimated cost of $279-million and estimated time of 10 yrs to

complete. The substation work will be performed concurrently and is estimated to cost $15.4M.

Attachment Facilities

The potential transmission solution will require a rearrangement of the existing Four Rivers 115 kV Substation (Figure A) to accommodate the proposed new generation. The proposed attachment facilities can be found in Figure B. The estimated cost of these facilities which also includes metering, protection equipment along with a 0.5 mile 115 kV line and associated equipment is $500,000 dollars and will be completed with the Direct Connection Network Upgrades.

Direct Connection Network Upgrades

The network attachment facilities include the installation of one 115 kV breaker and associated equipment and are estimated to cost $550,000 dollars. This work is estimated to take 12-18 months to complete.

Figure A
Existing Arrangement

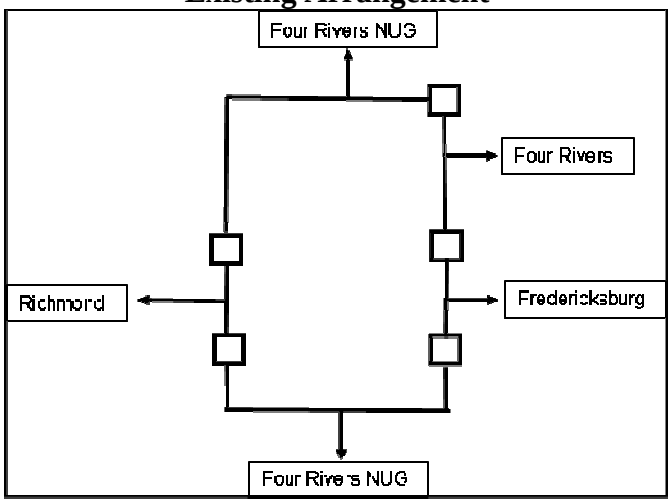
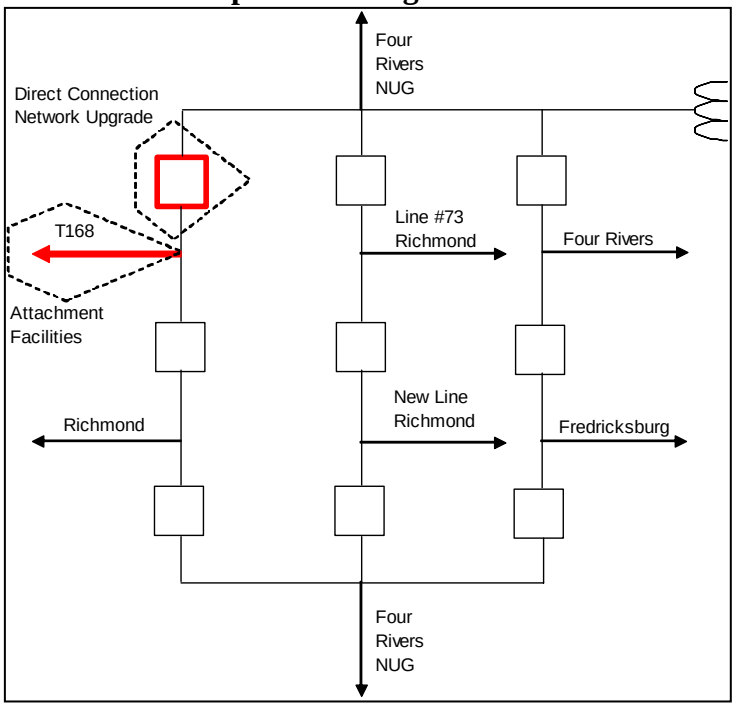


Figure B
Proposed Arrangement



OPTION: 500-kV

Network Impacts

The Queue Project #T168 was studied as a 1010MW injection at the Elmont 500-kV substation in the Dominion area. Project #T168 was evaluated for compliance with reliability criteria for summer peak conditions in 2012.

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

None.

Short Circuit

1) There are three (3) breaker interrupting capability with more than 100% as a result of T168 (500kV Option). It is as follow:

Bus	Breaker No.
Elmont 230 kV	283T2032
Ladysmith 500 kV	H1T552
Ladysmith 500 kV	H1T575

These results are subject to change due to changing system conditions.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

2) (BGE/PPL) The CONASTON-OTTERCRK 230kV line loads from 99.04% to 104.58% (DC power flow) of its emergency rating (627MVA) for the tower line outage (CONAS_PB). This project contributes approximately 34.7MW to cause this thermal violation.

3) (BGE/PPL) The GRACETON-MANOR 230kV line loads from 125.13% to 131.21% (DC power flow) of its emergency rating (531MVA) for the tower line outage (CONAS_PB). This project contributes approximately 32.3MW to the thermal violation.

4) (APS) The 01KEMPTN-N-NWEST 500kV line loads from 205.91% to 210.80% (DC power flow) of its emergency rating (2901MVA) for the tower line outage (HIRDG_BURTVL). This project contributes approximately 141.9MW to the thermal violation.

Stability Analysis
(Results of the dynamic studies should be inserted here)

To be determined at the System Impact Study.

Dominion Analysis
Dominion assessed the impact on the Dominion Transmission System that the proposed 1010 MW injection of new generation capacity would have at the Elmont 500 kV Substation. The system was assessed using the Summer 2012 RTEP case provided to Dominion by PJM for this analysis. This analysis did include the impacts that higher order queue generators may have on the study results, specifically those generators located on the Dominion Transmission System which have a signed a PJM ISA or IISA and their associated network upgrades were also modeled. The following higher order queue projects were modeled in the PJM Summer 2012 case; P16, P27, Q69, Q71, R17, R63, S86-S96 and T10. When performing a generation analysis Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions) and import/export system conditions. Dominion Criteria consider a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. For import /export studies Dominion considers a transmission facility overloaded if it exceed 100% of its emergency rating. A full listing of Dominion's Planning Criteria and interconnection requirements can be found in the Company's Facility Connection Requirements which are publicly available at "http://www.dom.com/about/elec-transmission/pdf/Facility_Connection_Requirements.pdf"

As part of its generation impact analysis Dominion routinely evaluates the impact that a proposed new generation resource will have under maximum generation conditions and stressed system conditions. For the T168 evaluation three different assessments were conducted.

1) The first being when local generation including the proposed T168 Facility is operated at their maximum capability. The result of this study is indicating significant system deficiencies and is shown below in Table A.

2) The second being a stressed system condition, specifically when the largest generator in the area is unavailable. The impact of T168 was studied under stressed system conditions where the most critical generating unit located on the 230 kV system in this load area is unavailable. Therefore, Possum Point Unit #5 was outaged to create this critical system condition. The result of this study is shown below in Table B.

3) The third being import and export conditions into and out of the Dominion System. Any new facility that is interconnected with the Dominion System should not significantly decrement FCITC between utilities. The results of these studies can be found in Tables C and D.

Table A
Summer 2012 Pmax System Conditions (Local Generators at Pmax)

Overloaded Element	Contingency Conditions	Pmax + T167
None		

Note: For this study condition generation at Possum Point, Birchwood and Four Rivers was scaled to its maximum value (Pmax) and generation was proportionally reduced throughout the PJM System.

Table B
Summer 2012 Stressed System Conditions (No Possum Point Unit #5)

Overloaded Element	Contingency Conditions	Base Case + T167
None		

Note: For this stress system condition Possum Point Unit #5 was removed from service and generation was increased within the Dominion System proportionally to make-up for the reduced generation.

Dominion's Planning Criteria also indicates a need to have approximately 2000 MW of import and export capability. The results of these import and export studies are indicating that the proposed generation facility will not impact Dominion's import or export capability.

Table C

Import Study Results			
Area	**Summer 2012**	**Summer 2012 with T167**	**Limiting Element**
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Table D

Export Study Results			
Area	**Summer 2012**	**Summer 2012 with T167**	**Limiting Element**
AEP	2000+	2000+	None
APS	2000+	2000+	None
CPL	2000+	2000+	None
PJM	2000+	2000+	None

Non-Direct Connection Network Upgrades

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

The estimated cost to replace the three over-duty breakers (item #1 above) is $1,180,000 and will take about 10 weeks to complete. The equipment order time will take about 8 to 10 months.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

This reinforcement addresses item #2 from the multiple facility contingency overloads listed above: The BG&E portion of the Conastone to Otter Creek line can be upgraded by reconductoring with 1,590 kcm ACSR from Gorsuch Mills to the Pennsylvania State Line (change of ownership to PPL). The length of this line section is 1.7 miles and its towers can be reinforced instead of replaced. The estimated cost and duration is $0.7M and 3 years. The PPL portion of the line can be upgraded by reconductoring approximately 17.2 miles with new 795 kcmil 30/19 ACSS. No terminal equipment upgrade is required at Otter Creek, it is currently built with 2000 amp rating equipment. The estimated cost of this upgrade is $8.5 million and the estimated construction time is 3 years.

This reinforcement addresses item #3 from the previously identified overloads listed above: Reconductor with 1,590 kcm ACSR from Graceton to PA line at an estimated cost and duration of $1.0M and 3 yrs. The length of this line section is 1.8 miles and its towers can be reinforced instead of replaced. The PPL reinforcement is to recondcutor with 1590 kcmil ACSR conductors (1 per phase). This rebuild will require new custom embedded steel poles to accommodate the larger conductor size. The rebuild will be 14.4 miles long and will travel the existing right of way. The estimated cost for this upgrade including substation terminal equipment cost is $31M.

This reinforcement addresses item #4 from the previously identified overloads listed above: Kemptown to North Northwest 500 kV reinforcement requires two single circuit lines at an estimated cost of $279-million and estimated time of 10 yrs to complete. The substation work will be performed concurrently and is estimated to cost $15.4M.

Direct Connection Network Upgrades

The transmission solution will require that two 500 kV lines each one being approximately 10 miles long be built from Four Rivers generation site to Elmont Substation. This is estimated to cost approximately $30 million dollars, excluding right-

of-way acquisition costs. The network facilities are estimated to take five years to complete.

Attachment Facilities

The proposed attachment facilities, which include metering, protection equipment along with a 0.5 mile 500 kV line and associated equipment is $ 650,000 dollars. This work is estimated to take 18-24 months to complete.

Figure A
Existing Arrangement