

Feasibility Study for Three On-Site Generators on Large Industrial Complex

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**TABLE OF CONTENTS**

<b>SECTION</b>	<b>PAGE</b>
<b>1.</b> Executive Summary .....	2
<b>2.</b> Description of Existing Substations .....	5
<b>2.A</b> Plant C Substations .....	5
<b>2.B</b> Plant A Substations.....	10
<b>2.C</b> Plant B Substation .....	14
<b>3.</b> Generator Sizing and Electrical Modifications Required.....	18
<b>3.A</b> General .....	18
<b>3.B</b> Plant C Generator .....	18
<b>3.C</b> Plant A Generator .....	21
<b>3.D</b> Plant B Generator .....	23
<b>3.E</b> Assumptions .....	26
<b>4.</b> Cost Estimate Analysis.....	30
<b>5.</b> Construction Issues.....	32
<b>6.</b> Conclusions.....	34

## **Section 1 – Executive Summary**

### **General**

The Owner of a large industrial complex is currently reviewing the possibility of installing emergency generation for its Plants A, B and C. This feasibility study confirms that this installation is feasible based on the information confirmed herein.

The proposed layouts and equipment arrangements discussed herein are based on the November 2002 site visit and on-site discussions with the Owner. All sizing information (i.e., cables, conduits, etc.) is preliminary and is provided for the cost analysis. The final sizes will be determined during final design.

The general approach for this study includes a discussion of the following key issues related to the installation of the generators and required auxiliary equipment:

- Description of Existing Substations (Section 2)
- Generator Sizing and Electrical Modifications Required (Section 3)
- Cost Estimate Analysis (Section 4)
- Significant Construction Issues (Section 5)

### **Cost Breakdown**

Following is a summary of costs based on the required work for the installation of the new generators and auxiliary equipment. Details are included in Appendix F (Cost Estimate Analysis).

The new generator permanent installation is estimated to cost approximately **\$700,000** for Plant C, **\$650,000** for Plant A, and **\$390,000** for Plant B. The generator rental permanent installation cost is approximately as follows: **\$170,000** for Plant C, **\$240,000** for Plant A,

Major Industrial Site – Eastern U.S.

and **\$130,000** for Plant B. This cost is installed and assumes a contingency and all associated engineering costs for the project.

The following is a cost summary of the project for permanent installation:

	<u>Plant C</u>	<u>Plant A</u>	<u>Plant B</u>
A.) Equipment.....	\$474,100	\$366,500	\$211,700
B.) Control System.....	\$10,000	\$10,000	\$10,000
C.) Conduit and Wiring (Installed).....	\$60,100	\$103,300	\$45,400
D.) Installation (Site Work and Modification).....	\$45,000	\$65,400	\$45,000
E.) A/E Design and Engineering.....	\$25,000	\$25,000	\$25,000
F.) Owner Engineering.....	\$5,000	\$5,000	\$5,000
G.) Construction Management.....	\$2,000	\$2,000	\$2,000
H.) Commissioning.....	\$20,000	\$15,000	\$7,000
I.) Contingency 10%.....	\$64,120	\$59,220	\$35,110
<b>TOTAL.....</b>	<b>\$705,320</b>	<b>\$651,420</b>	<b>\$386,210</b>

The following is a cost summary of the project for rental alternative:

	<u>Plant C</u>	<u>Plant A</u>	<u>Plant B</u>
A.) Equipment.....	\$57,000	\$59,100	\$39,700
B.) Control System.....	\$10,000	\$10,000	\$10,000
C.) Conduit and Wiring (Installed).....	\$60,100	\$103,300	\$45,400
D.) Installation (Site Work and Modification).....	\$15,000	\$35,400	\$15,000
E.) A/E Design and Engineering.....	\$8,000	\$7,000	\$5,000
F.) Owner Engineering.....	\$2,000	\$2,000	\$2,000
G.) Construction Management.....	\$1,000	\$1,000	\$1,000
H.) Commissioning.....	\$3,000	\$1,500	\$1,500
I.) Contingency 10%.....	\$15,610	\$21,930	\$11,960
<b>TOTAL OF PERMANENT INST.....</b>	<b>\$171,710</b>	<b>\$241,230</b>	<b>\$131,560</b>
<b>TOTAL OF MONTHLY RENTAL FEES.....</b>	<b>\$8,800</b>	<b>\$7,400</b>	<b>\$4,100</b>

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The majority of the cost for each facility will be the capital cost of the new generator for the permanent installation. In addition, there is significant conduit and cable routing both underground and exposed that will need to be closely coordinated with the existing equipment. Cost Estimate components are discussed in greater details in Section 4.

## **Section 2 – Description of Existing Substations**

### **2.A Plant C Substations**

The existing power for Plant C loads originate at the two double-ended unit substations Plant C-PD1 and Plant C-PD2. The Plant C-PD1 (A and B) unit substation is fed from line HV1 and HV2 respectively, and is located on the first floor in the South East corner of the facility. The Plant C-PD2 (A and B) unit substation is fed from line HV3 and HV4, respectively, and is located on the “interstitial” level on the South West corner of the facility. They are both unit type substations with 13.2kV-480/277VAC transformers feeding an “A” bus and a “B” bus via a main-tie-main arrangement. It is our understanding that the Owner operates their substations with the tie breaker open.

Each Plant C-PD1 transformer has an ambient air (OA) rating of 750KVA at 80 degree Celsius temperature rise and one stage of fans (FA) resulting in a 33% increase in KVA capacity (1000KVA). The substation has a combined FA rating of 2000KVA. Each transformer has an impedance of approximately 5.8%.

Each Plant C-PD2 transformer has an ambient air (OA) rating of 1000KVA at 150 degree Celsius temperature rise and one stage fans (FA) resulting in a 33% increase in KVA capacity (1334KVA). The substation has a combined FA rating of 2668 KVA. Each transformer has an impedance of approximately 5.51%.

This feasibility study includes the assumption that all loads are being furnished with standby power, even loads feeding power to other buildings.

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The unit substation circuit numbers and loads are as follows:

**Plant C-PD1 (A):**

*Circuit F1A* - This circuit feeds a panel designated LT-1-01 that feeds the Plant C emergency lights.

*Circuit F2A* – This circuit feeds a panel designated LT-1-02 that feeds the emergency lights.

*Circuit F3A* – This circuit feeds panel designated PD-1-02.

*Circuit F4A* – This circuit is a spare.

*Circuit F5A* – This circuit feeds a panel designated PD-1-03 in neighboring building .

*Circuit F6A* – This circuit is spare (wires tapped in mezzanine).

*Circuit F7A* – This circuit is a spare.

**Plant C-PD1 (B):**

*Circuit F1B* – This circuit feeds a panel designate PD-1-03 in neighboring building .

*Circuit F2B* – This circuit is spare (wires tapped in AP5 mezzanine).

*Circuit F3B* – This circuit feeds MCC designated PD-1-04.

*Circuit F4B* – This circuit is a space.

*Circuit F5B* – This circuit feeds MCC designated PD-1-05 in neighboring building.

**Plant C-PD2 (A):**

*Circuit 421A* – This circuit feeds MCC designated PD-1-06.

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*Circuit F2A* – This circuit is a spare.

*Circuit F3A* – This circuit feeds a panel designated PD-1-06.

*Circuit F4A* – This circuit feeds a panel designated PD-1-07 in neighboring building.

*Circuit F5A* – This circuit is a spare.

*Circuit F6A* – This circuit is a spare.

*Circuit F7A* – This circuit is a spare.

**Plant C-PD2 (B):**

*Circuit F1B* – This circuit feeds a panel designated PD-1-08.

*Circuit F2B* – This circuit feeds MCC designated PD-1-09.

*Circuit F3B* – This circuit is a spare.

*Circuit F4B* – This circuit is a spare.

*Circuit F5B* – This circuit is a spare.

*Circuit F6B* – This circuit is a spare.

*Circuit F7B* – This circuit is a spare.

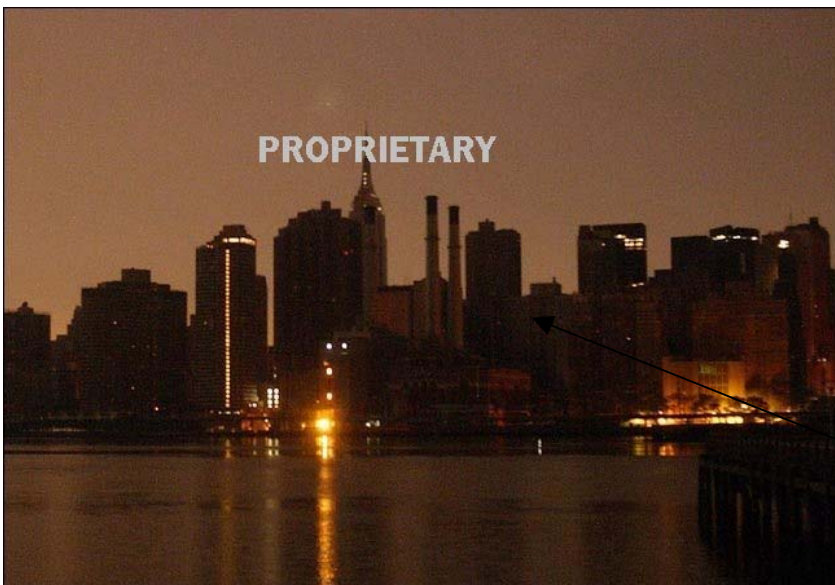
*Circuit F8B* – This circuit is a spare.

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The existing Plant C-PD1 substation located in the substation room is shown below:

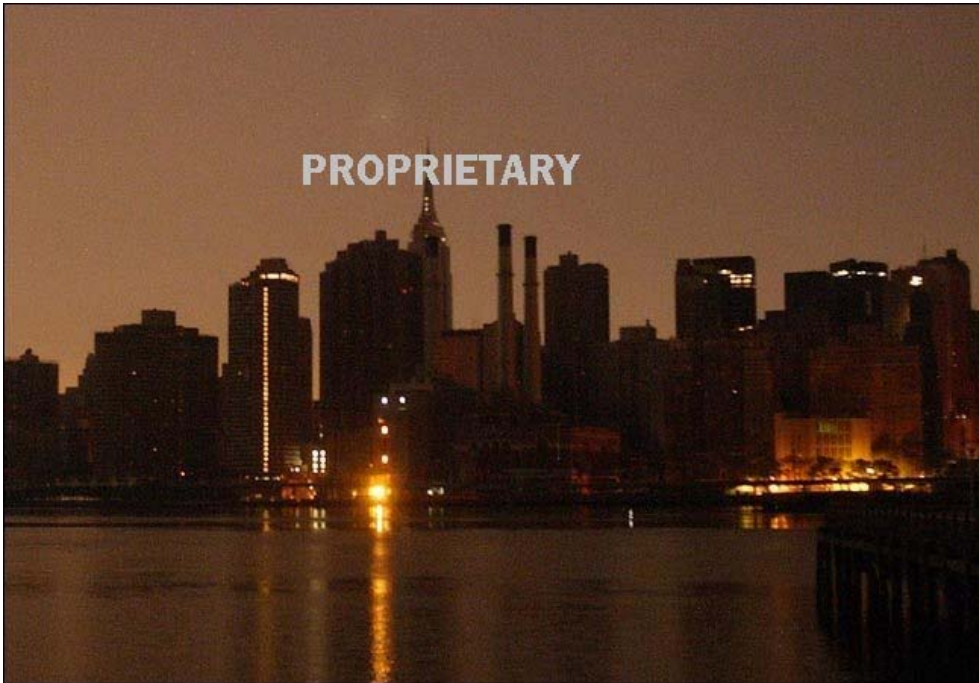


The existing Plant C-PD2 substation located in the substation room is shown below:

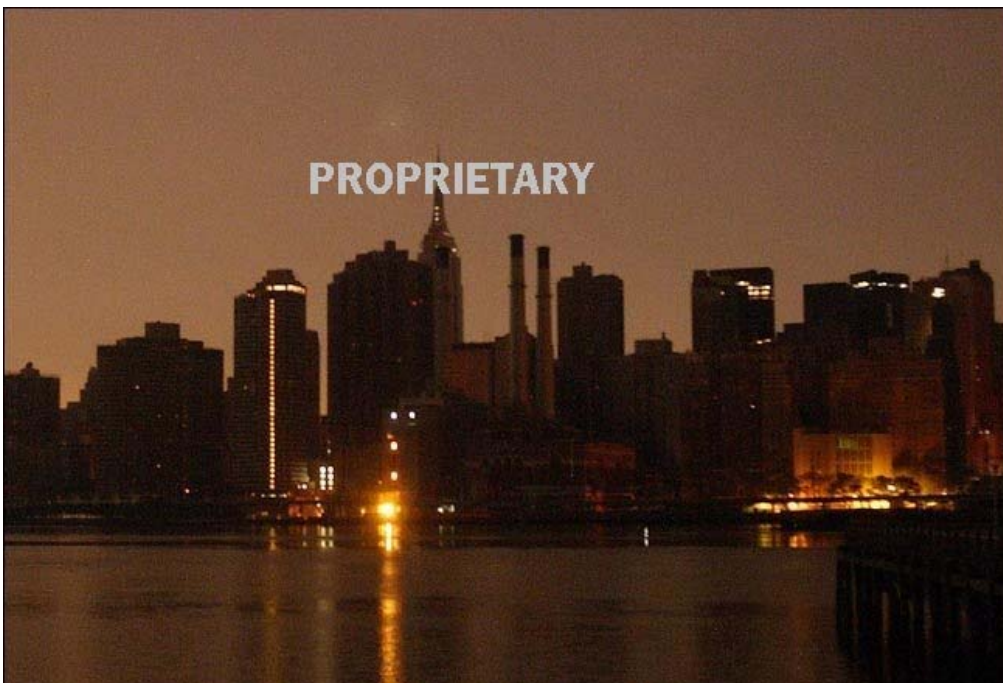


**Photo 1:**  
Existing Plant C-  
PD2 Substation

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**Photo 3:**  
Proposed Location of 15k



**Photo 4:**  
Proposed Location for the Remote Control and Annunciator Panel in Plant  
C-PD2 Substation Room

## **2.B Plant A Substation**

The objective of this study is to determine the feasibility of adding a dedicated standby generator at Plant A to provide power to the building loads.

The existing power for Plant A loads originates at the double-ended unit substation Plant A-PD1. The Plant A-PD1 (A and B) unit substation is fed from line HV5 and HV6, respectively. This is a unit type substation with 13.2kV-480/277VAC transformers feeding an “A” bus and a “B” bus via a main-tie-main arrangement. It is our understanding that the Owner operates their substations with the tie breaker open.

Each Plant A-PD1 transformer has an ambient air (OA) rating of 2000KVA at 80 degree Celsius temperature rise and one stage fans (FA) resulting in a 33% increase in KVA capacity (2667KVA). The substation has a combined FA rating of 5334 KVA. Each transformer has an impedance of approximately 5.75%.

This feasibility study includes the assumption that all the loads are being furnished with standby power, even loads feeding power to other buildings.

The unit substation circuit numbers and loads are as follows:

### **Plant A-PD1 (A):**

***Circuit F1A*** – This circuit feeds a panel designated PD-1-01 which is sub-feeding panels PD-1-02 and LP-1-01

***Circuit F2A*** – This circuit is spare.

***Circuit F3A*** – This circuit feeds a panel designated PD-1-03 which is sub-feeding panels PD-1-04 and MCC designated PD-1-05.

Major Industrial Site – Eastern U.S.

*Circuit F4A* – This circuit is a spare.

*Circuit 415A* – This circuit is a spare.

*Circuit 416A* – This circuit feeds a panel designated PD-1-06 in building Plant A.

**Plant A-PD1 (B):**

*Circuit 411B* – This circuit feeds a panel designated PD-1-07 which is sub-feeding MCC designated PD-1-08.

*Circuit 412B* – This circuit feeds a panel designated PD-1-09 which is sub-feeding panels PD-1-09 and PD-1-10.

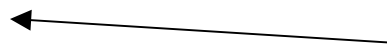
*Circuit 413B* – This circuit is a spare.

*Circuit 414B* – This circuit feeds a panel designated PD-1-11 in building Plant A.

*Circuit 415B* – This circuit is a spare.

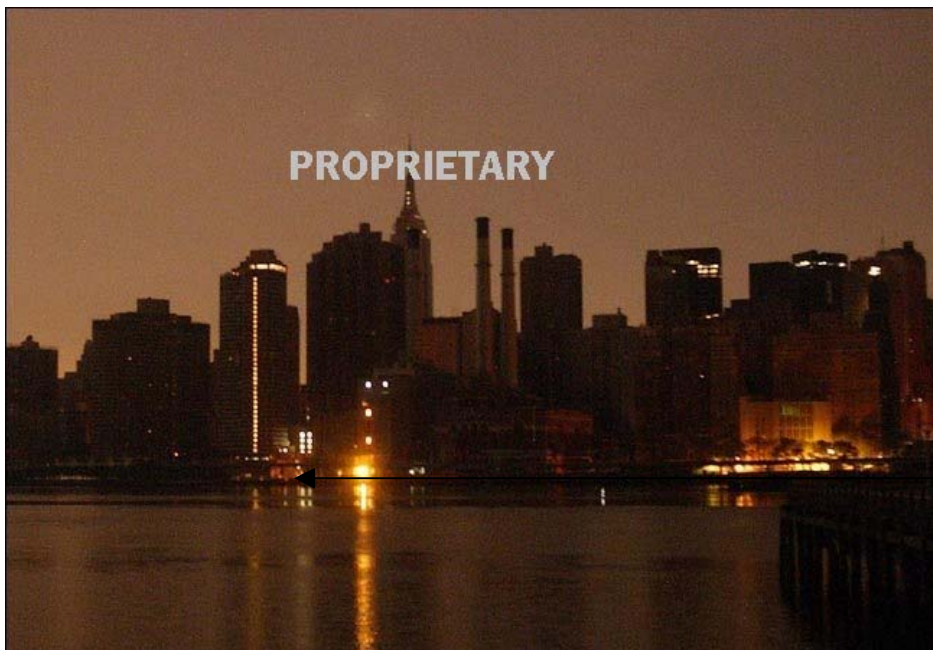
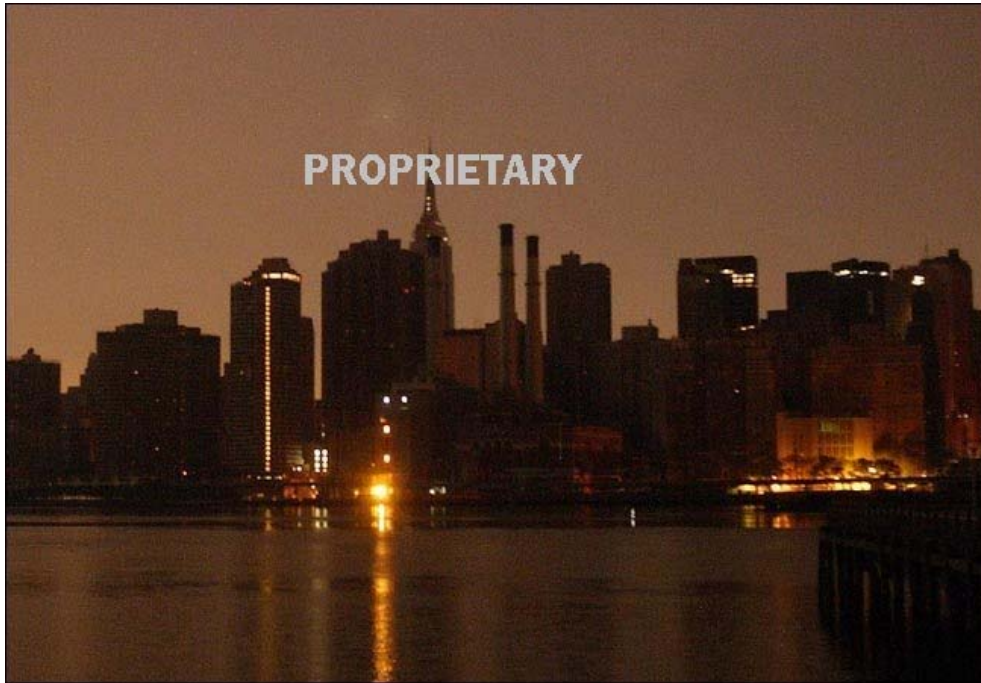
*Circuit 416B* – This circuit feeds MCCs designated PD-1-12 and PD-1-13

The existing Plant A-PD2 substation located in the substation room is shown below:



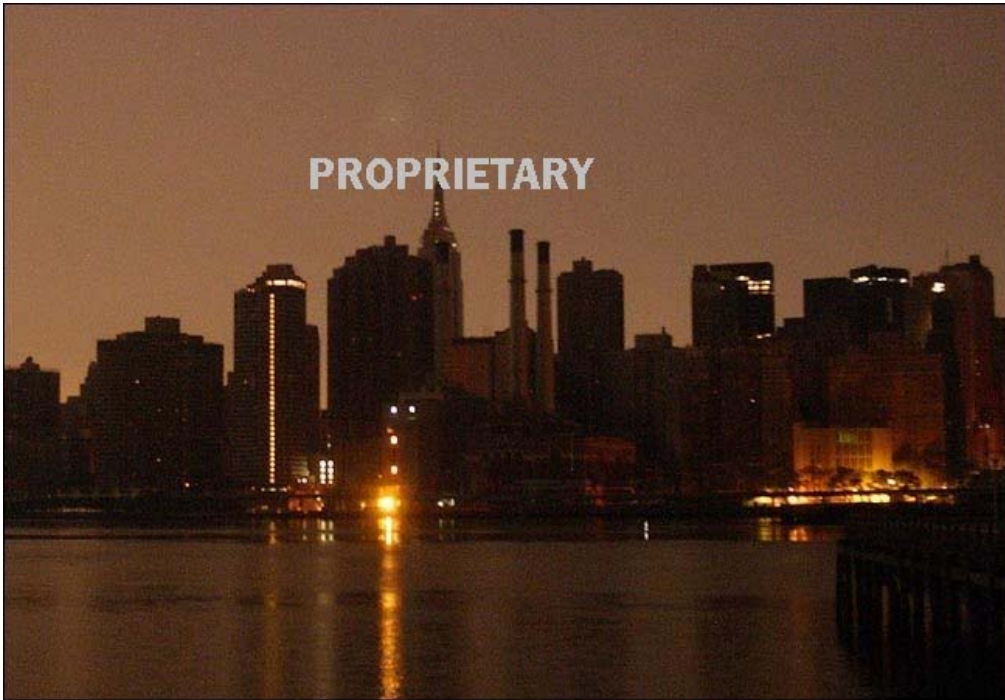
**Photo 5:**  
Existing Plant A  
Substation

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**Photo 6:**  
Existing Plant A  
Substation – Back View

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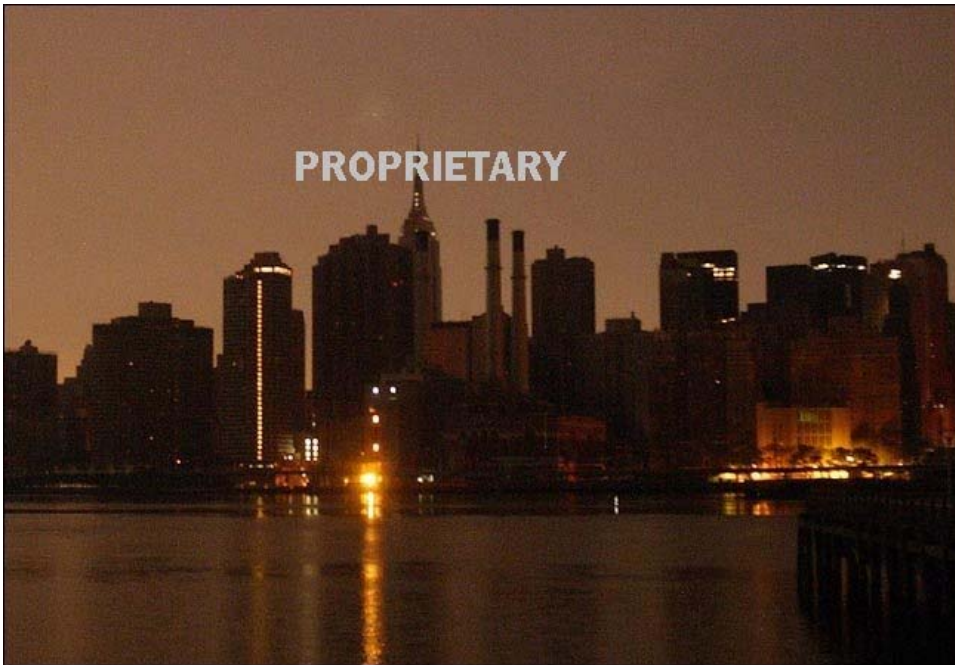
**Photo 8:** Cable Terminals for a Cummins Portable 2000KW, 480V Unit  
(All Connections are sized for 4/0 Cu Conductors)

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## 2.C Plant B Substation

The objective of this study is to determine the feasibility of adding a dedicated standby generator at Plant B to provide power to the building loads.

The existing power for Plant B loads originates at the double-ended unit substation Plant B-PD2. The Plant B (A and B) unit substation is fed from line HV5 and HV7, respectively and is located on the interstitial floor in the southeast corner of building Plant B. This is a unit type substation with 13.2kV-480/277VAC transformers feeding an



**Photo 9:**  
Proposed Location  
for the Plant A  
Diesel Generator

Major Industrial Site – Eastern U.S.

“A” bus and a “B” bus via a main-tie-main arrangement. It is our understanding that the Owner operates their substations with the tie breaker open.

Each Plant B-PD2 transformer has an ambient air (OA) rating of 1000KVA at 80 degree Celsius temperature rise and one stage of fans (FA) resulting in a 33% increase in KVA capacity (1334 kVA). The substation has a combined FA rating of 2668 kVA. Each transformer has an impedance of approximately 5.67%.

The substation has a total load of about 1030 kVA recorded on 8/22/02. There is a maximum amp demand of 1844A recorded on the PD2B meter that is an equivalent of 1530 kVA.

This feasibility study includes the assumption that all the loads are being furnished with standby power, even loads feeding power to other buildings.

The unit substation circuit numbers and loads are as follows:

**Plant B-PD2 (A):**

***Circuit F1A*** – This circuit is a space.

***Circuit F2A*** – This circuit is a space.

***Circuit F3A*** – This circuit feeds panel designated PD-1-01.

***Circuit F4A*** – This circuit feeds MCC designated PD-1-02.

***Circuit F5A*** – This circuit is the emergency service for “TS-1-01” ATS which feeds a MCC designated PD-1-03.

***Circuit F6A*** – This circuit is the normal service for “TS-1-02” ATS which feeds a MCC designated PD-1-04.

***Circuit F7A*** – This circuit feeds a panel designated Plant B PD-1-05 in building Plant B.

Major Industrial Site – Eastern U.S.

**Plant B-PD2 (B):**

***Circuit F1B*** – This circuit is a spare.

***Circuit F2B*** – This circuit is a spare.

***Circuit F3B*** – This circuit feeds a panel designated Plant B PD-1-06 in building Plant B.

***Circuit F4B*** – This circuit is the normal service for “TS-1-03” ATS which feeds a MCC designated PD-1-07.

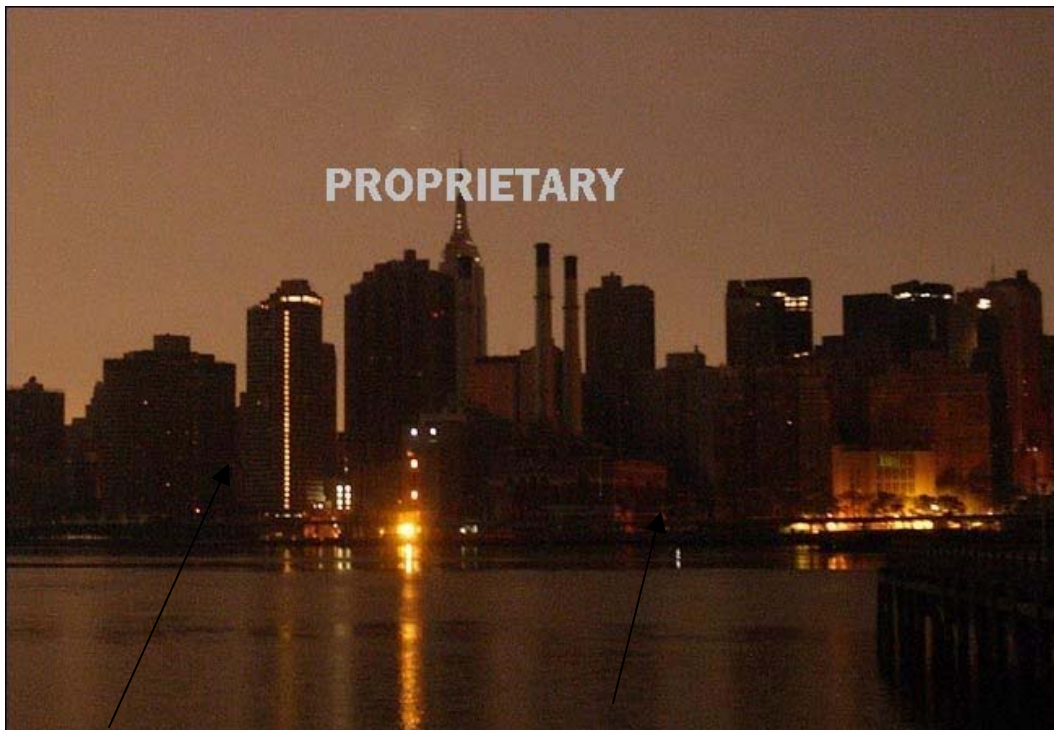
***Circuit F5B*** – This circuit feeds panel designated PD-1-08.

***Circuit F6B*** – This circuit feeds MCC designated PD-1-09.

***Circuit F7B*** – This circuit is a space.

***Circuit 418B*** – This circuit is the emergency service for “TS-1-04” ATS which feeds a MCC designated PD-1-10.

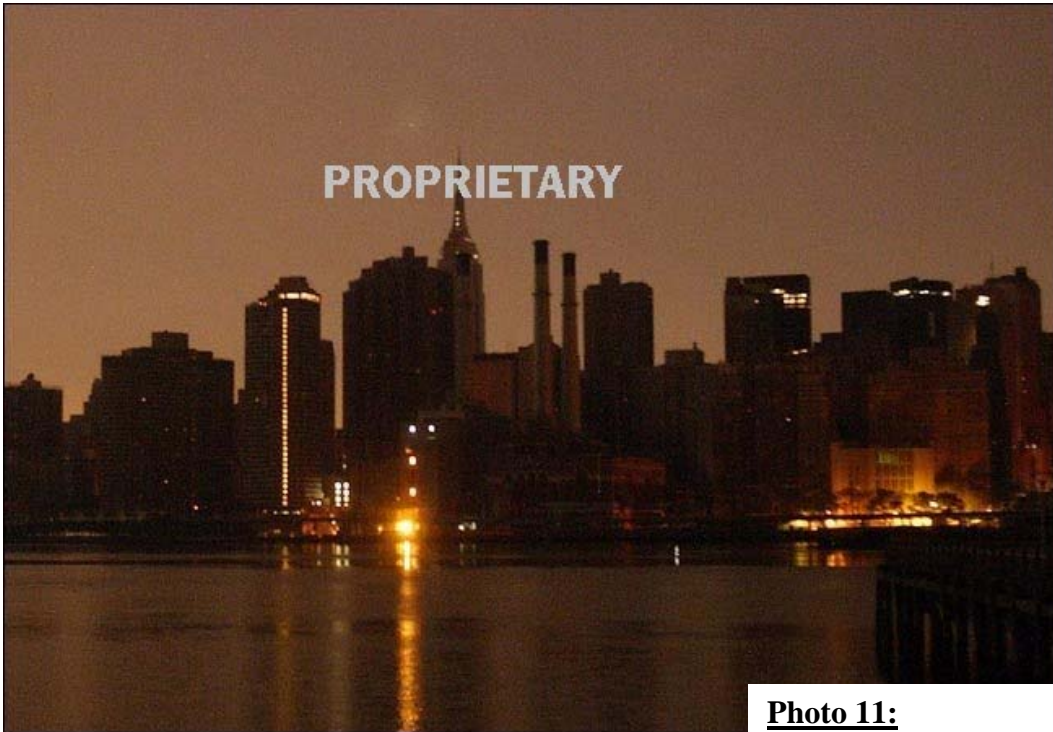
The existing Building Plant B-PD2 substation room is shown below:



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**Photo 10:**

Medium Voltage Junction Box  
Feeding Plant B-PD2 Substation –  
View 1



**Photo 11:**

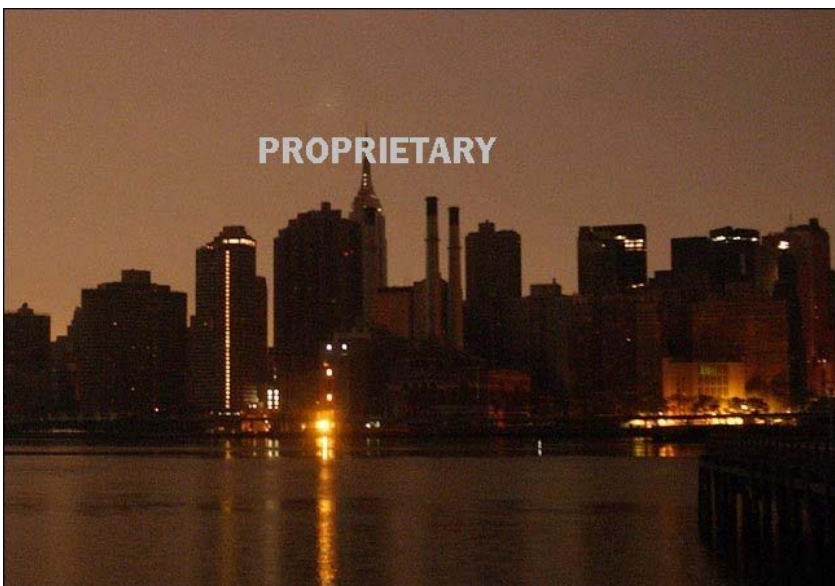
Medium Voltage Junction Box  
Feeding Plant B-PD2 Substation –  
View 2

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**Photo 12:**  
Proposed Location for the Plant  
B-PD2 Transition Bo  
(Disconnect Switch or  
Removable Links)

x  
Proposed location for Plant B diesel generator outside of Plant B building is shown  
below:



**Photo 13:**  
Available Space  
between Windows  
and Plant B-PD2  
Substation

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**Photo 14:**  
Proposed Location  
for the Plant B  
Diesel Generator

## **Section 3 – Generator Sizing and Electrical Modifications Required**

### **3.A General**

This feasibility study provides an analysis of the generator sizing and electrical modifications required for the emergency generator installation at Plant A, Plant B, and Plant C buildings.

As discussed with the Owner, the connection of the generator is not performed automatically. The connection of the emergency generation to the existing power system, for both the permanent installation and the rental installation, will be performed manually. This manual starting and required switching is estimated to take 1-2 hours, depending on personnel availability.

Upon loss of utility power, all feeder breakers at the main substation will be opened manually before manually starting the generator. After the generator reaches rated voltage and frequency, the generator circuit breaker will be manually closed. Then, the operator will proceed to close manually the breakers to feed the loads following an established sequence of operation required by the Owner's operational necessities. Further details of the sequence of operations are given on the permanent and rental one-line diagrams of the substations.

### **3.B Plant C Generator**

#### **Analysis**

The general position of the Diesel Generator (DG) is indicated on drawing 1 for the installation of a permanent generator. During the implementation stage, the precise location of the diesel enclosure will be established based on a survey of nearby utility lines, soil conditions, and architectural considerations.

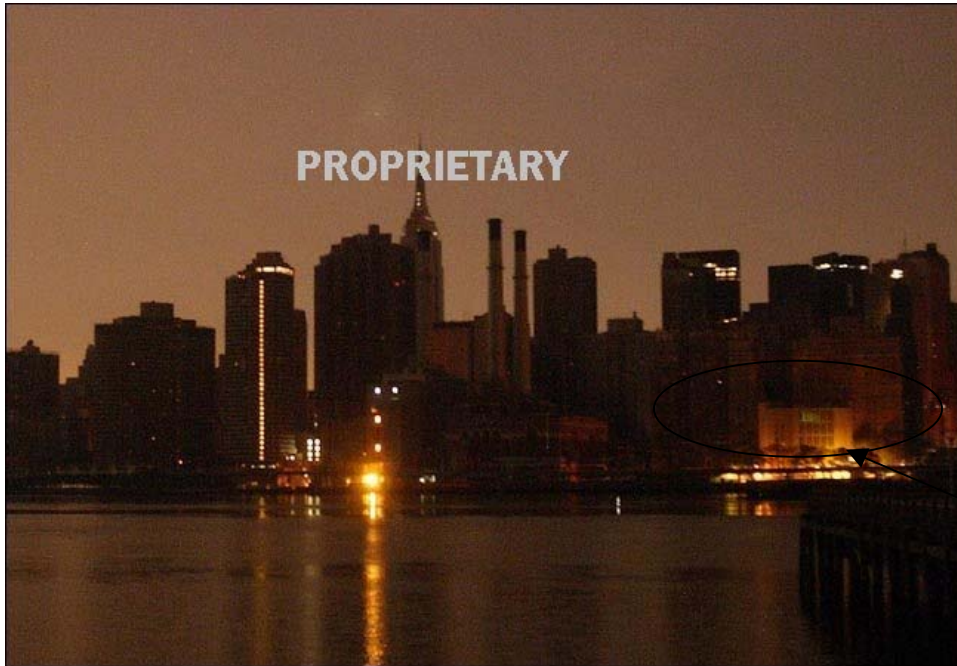
## Major Industrial Site – Eastern U.S.

The general arrangement inside the building is shown on drawings 2 and 3 for the permanent and rental generators respectively. The indicated runs are diagrammatic and the exact locations will be established after analyzing the raceway plan during detailed design. Cable pull-boxes will be provided as required.

Note that, to simplify construction and to obtain lower costs, the run to Plant C-PD1 will use an outdoor duct bank.

If the DG is a permanent emergency installation, a complete package diesel generator will be supplied, which will consist of the engine, generator, cooling system, fuel system, automatic starting system, control system and prefabricated weatherproof environmental enclosure. The generator will be connected to the Plant C's substations as indicated on the One-Line Diagram shown on drawing 4. The equipment to be provided under this contract is clearly identified on this One-Line Diagram.

If the emergency supply is to be provided by a portable diesel genset, the installation will consist of the outdoor switchgear and the downstream devices shown on drawing 5. The connection from the portable genset to the switchgear will be by means of portable MV cables equipped with terminals for quick connection. During the design stage, construction drawings for preparing the cable routing will be provided. Coordination with rental companies will be undertaken to prepare in advance cables with suitable terminations to connect to the portable power exits. Likewise, the rental companies will identify the requirements of their mobile units. It is our understanding that rental companies normally do not rent MV generators. The typical arrangement is to furnish 480 V units that are stepped-up to 13.2 kV. The physical arrangement construction drawings will incorporate the additional spacing requirement for this extra equipment.



**Photo 2:**  
Proposed Location  
for the Plant C  
Diesel Generator

### Considerations for Selecting Size and Voltage of the Plant C Generator

1. The PD1 substation has a FA rating of 2000 kVA ( $2 \times 750 \times 1.333$ ). The PD2 substation has a FA rating of 2667 kVA ( $2 \times 1000 \times 1.333$ ). Therefore, both substations have a combined rating of 4667 kVA.
2. On Aug 02, a total of about 540 kVA was recorded ( $.480 \times 1.73 \times 230 + .480 \times 1.73 \times 420$ ) for PD1 and 320 kVA was recorded ( $.480 \times 1.73 \times 265 + .480 \times 1.73 \times 115$ ) for PD2. Therefore, both substations had a combined loading of 860 kVA.
3. There is a max amp demand of 1354 A recorded on the PD1B meter. This equated to 1120 kVA for this double-ended substation. Likewise, there is a max amp demand of 857 A recorded on the PD2A meter. This equated to 710 kVA for this second double-ended substation. Therefore, both substations have a combined, non-coincidental, max demand of 1820 kVA.

4. By composing the long time delay settings of the PD2 feeders with a 30% diversity factor, a total of 810 kVA can be expected. No similar information is available for the PD1 feeder, but assuming the same composition as in PD2 we may project a similar load for PD1. PD1 is smaller (75% : 750/1000) but present larger accumulation ( 158%:1120/710). Therefore, we may anticipate a peak of 960 kVA (810\*.75\*1.58). Therefore, we may anticipate a simultaneous loading of 1770 kVA (810+960) on both substations.
5. Based on the above, a DG of 2000 kW (2500 kVA) seems reasonable. We have used this value for the feasibility study.
6. Due to the separation of the substations, it is desirable to place the connecting metal-clad switchgear close to the generator and run separate feeds to both substations from this switchgear. To simplify this arrangement, it is deemed appropriate to make this distribution with MV cables. So, a supply at 13200 V appears to be the better choice. We will assume this voltage for the feasibility study.

### **3.C PLANT A Generator**

#### **Analysis**

The general position of the Diesel Generator (DG) is indicated on drawing 6 for the installation of a permanent generator. During the implementation stage, the precise location of the diesel enclosure will be established based on a survey of nearby utility lines, soil conditions and architectural considerations.

The general arrangement inside the building is shown on drawings 7 and 8 for the permanent and rental generators respectively. The indicated runs are diagrammatic and

## Major Industrial Site – Eastern U.S.

the definite locations will be established after analyzing the raceways plans and a detailed inspection. Cable pull-boxes will be provided as required.

The connection of the Plant A-PD1 substation will be performed by a cable exiting the generator housing and transitioning to a metal enclosed busway before it enters the 480 V substation. During the implementation stage, the manufacturer of the double-sided substation will inspect the switchgear cubicles to find the most suitable solution and will furnish details for connection to the existing substation.

For the rental alternate drawing 9 shows the connection of the generator cables to an outdoor cable connection box. This box will connect upstream to the portable generator cables, and downstream to the permanent leads to the substation. An orderly arrangement of such a large number of conductors shall be provided as in the example of [Photo #8](#). Pull-boxes will be provided as required.

[Photo #7](#) shows a picture of the route that will be used to carry the cables in the spaces between the ceiling and the concrete slab. A length of less than 100 feet is expected.

There is no need for outdoor switchgear for the permanent generator.

If the DG is a permanent emergency installation a complete package diesel generator will be supplied, which will consist of the engine, generator, cooling system, fuel system, automatic starting system, control system and prefabricated weatherproof environmental enclosure. The generator will be connected to the Plant A-PD1 substation as indicated on the One-Line Diagram as shown on drawing 10. The equipment to be provided under this contract is clearly identified on this One-Line Diagram.

As shown on this diagram the generator leads connect to the substation bus via a 3200 A switch or removable links. Although we have prepared estimates based on a quote from a switch manufacturer, there is a reduced space to locate it. During the implementation, the removable links alternate will be pursued due to the lower costs and smaller size.

## Major Industrial Site – Eastern U.S.

If the emergency supply is to be provided by a portable diesel genset, the installation will consist of the outdoor cable connection box and the downstream devices shown on drawing 11. The connection from the portable genset to the cable connection box will be by means of portable LV cables equipped with the terminals for quick connection. During the implication stage, construction drawings for preparing the cables will be provided. Coordination with rental companies will be undertaken to furnish the cables with suitable terminations to connect to the portable power exits. Photo #8 shows the power connections of a portable 2 MW generator provided by a leading manufacturer. Note that for versatility, 8 cam-lock connectors (“banana type”) are furnished to the left, together with 8 power block terminals to the right. During the implementation stage, an analysis of these and other types will be undertaken. The recommended arrangement will also take into account compatibility with present the Owner’s practices.

### **Considerations for Selecting Size and Voltage of the Plant A Generator**

1. The Plant A-PD1 substation has a combined FA rating of 5334 kVA ( $2 \times 2000 \times 1.333$ ).
2. On 8/22/02, a total of about 1900 kVA was recorded ( $.480 \times 1.73 \times 860 + .480 \times 1.73 \times 1410$ ).  
On 12/06/02, a total of about 2120 kVA was recorded ( $.480 \times 1.73 \times 950 + .480 \times 1.73 \times 1600$ ).
3. There is a max amp demand of 2963 A recorded on the PD1B meter. That is total of 2460 kVA for a particular happening when the double-ended substation was fed temporarily from one end.
4. By composing the long time delay settings of the feeders with a 25 % simultaneity factor, a total of 1940 kVA can be expected.

## Major Industrial Site – Eastern U.S.

5. Based on the above, a DG of 2000 kW (2500 kVA) seems reasonable. We will use that value on the feasibility study. During the implementation of the EPSS, a better evaluation of loads will determine the actual size of the DG.
6. The anticipated location of the DG needs a run of about 120' to the substation. So, a supply at 480 V appears to be feasible. We will assume this voltage for the feasibility study. During the implementation of the EPSS, a better analysis of the arrangement will determine the actual supply voltage to the DG.

### **3.D Plant B Generator**

#### **Analysis**

The general position of the DG is indicated on drawing 12 for the installation of a permanent generator. During the implementation stage, the precise location of the diesel enclosure will be established based on a survey of nearby utility lines, soil conditions and architectural considerations.

The general arrangement inside the building is shown on drawings 13 and 14 for the permanent and rental generators respectively. The indicated runs are diagrammatic and the definite locations will be established after analyzing the raceway plans and detailed design. Cable pull-boxes will be provided as required.

The connection of the Plant B-2 substation will be performed by a cable exiting the generator housing and transitioning to a metal enclosed busway before it enters the 480 V substation. During the implementation stage, the manufacturer of the double-sided substation will inspect the switchgear cubicles to find the most suitable solution and will furnish details for connection to the existing substation.

For the rental alternate drawing 15 shows the connection of the generator cables to an outdoor cable connection box. This box will connect upstream to the portable generator

## Major Industrial Site – Eastern U.S.

cables, and downstream to the permanent leads to the substation. An orderly arrangement of such a large number of conductors shall be provided as in the example of **Photo #8**. Pull-boxes will be provided as required.

As photos **#10, 11 and 14** indicate, the route that will be used to carry the cables will be very short. Photo #13 shows the ample available space that will simplify the arrangement and installation work.

There is no need for outdoor switchgear for the permanent generator.

If the DG is a permanent emergency installation a complete package diesel generator will be supplied which will consist of the engine, generator, cooling system, fuel system, automatic starting system, control system and prefabricated weatherproof environmental enclosure. The generator will be connected to the Plant B-2 substation as indicated on the One-Line Diagram indicated on drawing 16. The equipment to be provided under this contract is clearly identified on this One-Line Diagram.

As shown on this diagram the generator leads connect to the substation bus via a 1600 A switch or removable links. Although we have prepared estimates based on a quote from a switch manufacturer, there is a reduced space to locate it. During the implementation, the removable links alternate will be pursued due to the lower costs and smaller size.

If the emergency supply is to be provided by a portable diesel genset, the installation will consist of the outdoor cable connection box and the downstream devices shown on drawing 17. The connection from the portable genset to the cable connection box will be by means of portable LV cables equipped with the terminals for quick connection. During the implication stage, construction drawings for preparing the cables will be provided. Coordination with rental companies will be undertaken to furnish the cables with suitable terminations to connect to the portable power exits. Since this is a 1100 kW unit requiring only 5 conductors per phase, the arrangement for the power cables will be simpler than the one shown in **Photo #8**.

### **Considerations for Selecting Size and Voltage of the Plant B Generator**

1. The PD2 substation has a combined FA rating of 2667 kVA ( $2 \times 1000 \times 1.333$ ).
2. On Aug 02, a total of about 1030 kVA was recorded in PD1 ( $.480 \times 1.73 \times 520 + .480 \times 1.73 \times 720$ ).
3. There is a max amp demand of 1844A recorded on the PD2B meter. That is total of 1530 kVA for a particular happening when the double-ended substation was fed temporarily from one end.
4. The substation tie bus has a current-carrying capability of only 1600A (1328 KVA or 1062 kW at .8 PF).
5. Based on the above, a DG of 1100 kW (1375 kVA) seems reasonable. This rating will not impose an overload on the existing substation. If a load in the level of the recorded in Par. 3 materializes during the emergency operation, operators could load shed to avoid overload of the generator.
6. We will use the 1100 KW rating in this feasibility study. During the implementation of the EPSS, a better evaluation of loads and operating needs will determine the actual size of the DG. If a larger unit is contemplated, the switchgear manufacturer should be consulted about upgrading ampacities beyond 1600A limitation.
7. The anticipated location of the DG needs a run of less than 100' to the substation. So, a supply at 480 V appears to be feasible. We will assume this voltage for the feasibility study. During the implementation of the EPSS, a better analysis of the arrangement will determine the actual supply voltage to the DG.

### **3.E Assumptions**

This feasibility study includes the following assumptions utilized for sizing equipment, preparing the physical arrangements, and preparation of the cost estimates:

1. It is assumed that the loads served from the subject substations are not critical thus, the connection of the generators does not need to be performed automatically and can be connected manually. After the generators are manually started, the operators will proceed to restore service to the loads by manually closing the breakers and following an established sequence of operations. These operating procedures will be prepared in accordance with operational requirements furnished by Owner.
2. Loading the generator in pre-arranged steps is not being considered in this study. Operators will perform the load increases manually and may decide load adjustments to fit the particular conditions during the emergency operation.
3. As shown in the furnished worksheets, the estimates of the installed conduit and wiring is based on the assumed arrangements and using the material and labor figures presented in R.S. Means “2002 Electrical Cost Data”. In addition, the recommended pricing from this guide includes the projected costs at the local area, and the overheads, and profits markups expected from electrical contractors.

## **Section 4 - Cost Estimate Analysis**

The following are comments related to the quotations and the cost estimate:

- **Equipment**

To estimate the costs of each diesel generators, budgetary quotes were requested from a leading manufacturer using a current specification requirements. Copies of the vendor's proposals are attached.

Likewise, budgetary quotes were requested from switchgear manufacturers.

For the rental configuration of Plant A and Plant B units, the attached 4000A quote was used with the assumption that both Plant A and Plant B cable connection boxes will have a comparable cost. For the 13.2 kV switchgear, the attached quote from a vendor was utilized.

For the substation improvements to connect the Diesel Generators no manufacturer's quotations were available. The presented values are engineering estimated based on conversations with manufacturers after the inspection of Dec 02. The manufacturer estimates this cost at approximately \$28,000.

- **Control System**

The presented amounts are engineering estimates for the additional requirements included in the current specification such as the second (remote) Control and Annunciator Panel, and a telecommunication link to the manufacturer's offices for remote monitoring in real time.

- **Installed Conduit and Wiring**

The presented amounts have been estimated based on the expected loads and locations of the Diesel Generators, substations and conduit runs. The calculations are indicated on the attached worksheets. During the detailed design, a field inspection jointly with a qualified electric contractor will be undertaken to identify the available routes.

## Major Industrial Site – Eastern U.S.

- Installation

The generator foundation cost is an engineering estimate based on the expected weight and dimension of the Diesel Generators.

The general installation approximation is an engineering estimate based on the anticipated requirements of personnel and construction equipment.

- A/E Design and Engineering, Owner Engineering, Construction and Management, and Contingencies

These amounts are engineering estimates using rates normally used by the industry for the subject type for an industrial project.

- Rental Alternates

The presented estimates assume that the installations will be ready for quick-connection to the portable Diesel Generators. Therefore, it is necessary that permanent installations will be installed and commissioned. The amounts are the same as the presented in the permanent estimates and adjusted as required.

The rental fees were obtained from a leading leaser of emergency power supplies. As shown on the attached proposals, in addition to the chosen coverage (5 hour response time), there are other options with higher and lower costs.

- Firewall for Plant A Generator

The shown location for this unit is very close to building Plant A. On the right side, there are doors and windows unprotected against fires. To comply with the NFPA code, this unit is being provided with firewall protection on 3 sides. The estimate takes into account the data for a 9” solid brick wall furnished from the “2002 BNI Building News Costbook”. If the alternative location presently under consideration on the neighbor building, SW corner materializes, this expense may be adjusted..

## **Section 5 - Construction Issues**

The following is a list of construction issues that we feel are of significant importance and will need to be addressed during the design phase of the project:

1. The connections of the generator leads to the substations require important modifications of the receiving cubicles on site. For the LV supplies (to Plant A -PD1 and PD-2), the modifications will be similar as the recommended for a similar facility with 3200 A, 480 V, as the result of the manufacturer's visit of December 3, 2002. This inspection confirmed the feasibility of a "busway" connection to bus and rendered an engineering estimate of the cost. For the HV supplies (Plant C-PD1 and Plant C-PD2), a specialized manufacturer has been consulted and furnished comments. Although the proposed connections are feasible, presently there are no specific guidelines nor cost estimates. During the implementation, the manufacturers will be called for inspections to propose the specific details for connection to the existing substations.
2. The field connection of the LV busways to the substations busses as well as the MV cable connections to the 15 kV fuses, will be coordinated with the plant staff to deal with any discontinuation of service. Strict compliance with the applicable safety standards shall be exercised to avoid any catastrophic damage to Owner property or injuries to personnel.
3. The indicated locations of the diesel generators and building entrances for the permanent and rental installations are preliminary and based on visits and discussion with Owner. These positions must be confirmed by a survey of utility lines, environmental requirements and soil borings that should be undertaken by Owner at earliest opportunity.

Major Industrial Site – Eastern U.S.

4. A detailed inspection with a specialized electrical contractor will be necessary to confirm the chosen routing and define the location of conduits, pull-boxes and floor and wall penetrations.
5. There are space limitations to the location of the proposed equipment in the Plant A-PD1 substation. In order to overcome these restrictions, detailed discussions shall be hold with the switchgear manufacturer and fabricators to obtain components (probably custom-made) that suit the project objectives.

## **Section 6 – Conclusions**

It appears based on this analysis that it is feasible to install diesel-generators to back-up loads at Owner Buildings Plants A, B and C. There are several assumptions that have been made in this report which help to form part of this conclusion.

No major issues exist that would prevent the installation and/or hinder the decision to install this equipment. There are fairly significant design issues that will need to be investigated and confirmed during detailed design. However, these issues are routinely encountered in retrofit and rehabilitation projects and can be overcome with the right planning and attention to detail.

During construction and start up, connections of the generators to the existing substations shall be coordinated in detail with plant management and staff to insure continuation of vital services at all times. Strict compliance with the applicable safety standards shall be exercised to avoid any catastrophic damage to Owner property or injuries to personnel.