

# An End-User's Guide to Selecting AC/DC Power Plant Architecture Bulk vs. Distributive

Michael R. Moore  
Moore & Moore Solutions, Inc.  
288 Rivercrest Drive  
Phoenixville, PA 19460 USA

[mike@mooreandmooresolutions.com](mailto:mike@mooreandmooresolutions.com)

**Abstract –** With recent advancements in densely packed switchmode -48VDC rectifier designs, a new era of battery technologies such as Lithium Ion (LI) and Lithium Metal Polymer (LMP), the rising cost of copper and the latest National Electrical Code (NEC2005), it's time again to revisit the Distributive vs. Bulk question. The intent of this paper is to assist an end-user in determining which DC Power Plant architecture to select when designing a Telecommunication equipment room layout.

This paper will take into account the majority of considerations to be addressed when selecting an AC/DC Power Plant Architecture. The models will be presented by one (1) Bulk Solution and three (3) Distributive Solutions.

## I. THE PROBLEM

Design an Equipment Room with dimensions of 88'-6" x 136' x 16' not including the generator room. The proposed solutions must meet DC generic requirements for installation [1], generic requirements for engineering [2] and NEC2005 procedures and practices. The optimal design will be the most cost effective solutions supplying the load, while adhering to the required protection time, maximizing the available real estate to install the largest number of revenue producing equipment racks in the space.

## II. THE ASSUMPTIONS

The -48VDC load is 9600Amp load with a generator on site; the battery reserve time must protect for 4 hours at full load.[3] All proposed power plant designs must utilize an N+1 standard for rectifiers to ensure surplus capacity to recharge the battery strings/modules, while still delivering the full load, in a reasonable amount of time.

The project site's Service Entrance (SE) is 480VAC – 3phase – Y configuration – 4000Amps. The switchboard and Generator are both rated at 480VAC - 3 phase. Only 480VAC – 3phase service is available from the power utility.

Since time is money, the sooner the site is Ready For Service (RFS), the faster the revenue producing equipment can start contributing to the end-user's bottom line. All model pricing must be valid to be Engineered, Furnished and Installed Anywhere, Continental USA by a qualified vendor.

## II. EF&I VENDOR MARKETING CONDITIONS

The question typically asked by an end-user is what vendor should be utilized to EF&I this project. Selection of the wrong vendor can have devastating consequences, in the event of service interruption, missing Ready for Service dates and/or going over assigned budget. To help select the proper EF&I vendor one must first understand the marketing conditions that these architects must navigate. Please see paper included in these 2006 Intelec Proceeding entitled: "The Telecommunications Act of 1996 – Analysis a Decade Later" for EF&I Vendor marketing conditions.

## IV. SIZING THE POWER PLANT(S) TO THE LOAD

All possible solutions offered will be sized according to typical RBOC, Wireless Carrier and CLEC end-user specifications for proper NEC2005 and best electrical practices and procedures for heat generation when sizing the following: current carrying conductors, neutrals, distribution, transformers, demand load, equipment ground, conduit sizes and Surface Metal Raceway.

### A. Sizing Current Carrying Conductors

It is amazing how many people really don't understand how to perform this task to NEC 2005 standards. First, it must be understood that a current carrying conductor is sized to the amp rating of the circuit breaker/fuse to which it is fed. The breaker is there primarily to protect the current carrying conductor from seeing more current than it is sized to. Second, when sizing conductors you take the full rating of the circuit breaker/fuse. Third, when sizing current carrying conductors, the code requires the following before selecting any ampacity table temperature column. NEC2005 110.14(1)(a)(b) page 110.16 states:

Any circuits  $\leq$  100Amps or #14 Awg  $\leq$  circuits  $\leq$  #1 Awg shall use only the conductor 60°C Table. Any circuits  $>$  100Amps or Circuits  $>$  #1Awg shall use only the conductor 75°C table.

Fourth, how many current carrying conductors are you running through the conduit or cable? If greater than 3 current carrying conductors, you must use Table

310.15(B)(2)(a) Adjustment Factors for More than Three Current Carrying Conductors in a Raceway or Cable. It is only once all the above are determined that you can apply the proper factors to the ampacity tables. While it may be true we are using THHN and Table 310.16 provides a column for THHN under the 90°C, this value is the maximum allowable typically for these types of wire jackets. This is very important because in a large % of the site walk-thrus that I have performed over the years, the conduits feeding rectifiers, are warm to 90°C hot to the touch. Remember water boils at 100°C. With all the expense associated with HVAC systems, why contribute to the heat issue when it can be easily avoided by sizing conductors correctly.

No AC voltage drop derating was used when sizing AC current carrying conductors for the proposed solutions, due to the distance required before derating is required. All AC and DC pricing and sizing is based on copper conductors.

For the Bulk model solution offered, the battery string conductors are not tied to any circuit breaker or fuse, the cables in this case have been sized to the string's 4 hour rate to 1.88vpc with 0.2V loop drop. The battery fuse/breaker disconnect is something the end-user has always viewed as another point of potential failure. Thus they are not used.

#### *B. Sizing Neutral Conductors*

Due to the harmonics associated with switchmode technology, a good practice is to oversize your neutrals times two (2). Due to the non-linear loads associated with switchmode rectifiers, a standard size neutral could experience more current than sized to and may get hot. 200% Neutrals will require a special order when selecting panelboards and K-Factor Type Transformers are required. Some studies have found this practice not required, stating even under very unusual situations where the phases are fully loaded and unbalanced, the neutral current only slightly exceeds 100% on 480VAC Y systems and in 208VAC Y/120VAC states that although theoretical levels of 113% to 130% are possible at 400Amp and higher, to the study's knowledge, no site measurements exist that exceed 100% of rating at these current levels.[5] With all that is known, it is the best electrical practice with respect to heat generation, if designing a new system, to incorporate the 200% neutrals into end-user's AC Power designs.

#### *C. Sizing Demand Load*

This is another place where a lot of arguments come to meet. Example: For the Distributive solutions offered utilizing (1)-48Rectifier shelves that require an AC input circuit of (1) 90Amp – 208VAC - single phase connection to produce 250Amp of DC output. First, due to the input voltage of service entrance being 480VAC – 3 phase, all the Distributive Solutions offered in this paper will have a Transformer Bank Plant to produce 208VAC – 3 Phase from here 2 pole breakers 90Amp -208VAC Single Phase are used to bring L1, L2 and GN to the Rectifier Shelf. The requirement of sizing the transformer takes some planning first because the code restricts the number of circuit breakers coming from a panel to 6.[9] This limits the number of

rectifier shelves one can feed from a single panelboard to 6 or 3 distributive plants.

#### Demand Load Calculations

$$\frac{90\text{Amps}}{1.25} = 72 \text{ Amps } 208\text{VAC} - 1 \text{ phase}$$

#### Single Phase Amps to Three Phase Amps Calculations

$$\frac{72\text{Amps}}{1.73} = 41.61 \text{ Amps } 208\text{VAC} - 3 \text{ phase}$$

Where

1.25 = typical oversize when selecting the breaker to the load.

1.73 = square root of 3 which is the multiplier from Three phase Amps to Single phase Amps.

#### *D. Sizing Transformers and Panelboards*

Total Load on each secondary side of the Transformer and the Panelboard tied to it = 3 power plants or 6 shelves

$$41.61\text{Amps} \times 6 = 249.66\text{Amp } -208\text{VAC} - 3 \text{ phase}$$

Maximum Current of selected 112.5KVA Transformer used for the distributive solutions are K- Factor Type with K=30 the 480VAC Primary and 208VAC secondary all 3 phase = primary 135Amps-480VAC and 312Amp-208VAC all 3 values 3 phase.

Total Overcurrent Protection device on Primary Side of the Transformer size to maximum is 135Amps-480VAC

$$135\text{Amps} \times 2.5 = 337.5\text{Amps} = 400\text{Amp Breaker}$$

Total Overcurrent Protection device on the Secondary Side of the Transformer is 312 Amps.

$$312 \text{ Amps} \times 1.25 = 390\text{Amp} = 400\text{Amp Breaker}$$

Transformer's overcurrent protection devices are required to be oversized per NEC2005 Table 450.3(B) Maximum Rating or Setting of Overcurrent Protection for Transformers 600VAC and less (as a Percentage of Transformer-Rated Current), here the code requires 250% on the primary and 125% on the secondary for Transformers less than 600VAC.

Each of the 8 panelboards are sized to the overcurrent device for which they are fed. Here each 208VAC – 3 phase panelboard will be 400amps e/w with (6) 90Amp -208V – single phase – 2 pole breakers.

To meet the 9600Amp -48VDC requirement 44 rectifier shelves will be needed, so the total number of transformers for the distributive solutions will be (8) 112.5KVA Transformers feeding (8) 400Amp -208VAC -3phase Y configuration panelboards with 200% neutrals.

#### D. Sizing Conduits

This is a simple math problem, you have so much copper diameter going through so much diameter of conduit. First go to NEC2005 – Chapter 9 (Tables) – Table 5 Type: RHH\*, RHW\*, RHW-2\*, THHN, THHW, THW, THW-2, TFN, TFFN, THWN, THWN-2, XF, XFF - Row Type: THHN, THWN, THWN-2 to determine the diameter(s) of the selected wire type(s). Then go to NEC2005 – Chapter 9 (Tables) – Table 4 Article 358 – Electrical Metal Tubing (EMT) and Table 4 Article 350 – Liquidtight Flexible Metal Conduit (LFMC) to determine trade size of conduit. Normally using Over 2 wires in one (1) conduit = 40% of cross sectional fill inside the conduit. For Nipples you can use 60% column on these tables.

#### E. Sizing Surface Metal Raceways

For the distributive solutions presented in this paper I have decided to run a surface metal raceway system. First you must know the rules of this electrical component in the eyes of the NEC2005 386.22 (Number of Conductors or Cables) installed in a surface metal raceway. Derating factors of 310.15(B)(2)(a) Adjustment Factors for More Than Three Current Carrying Conductors in a Raceway or Cable shall not apply to conductors where all the following conditions are met:

- (1) The cross sectional area of the raceway exceeds 2500 mm<sup>2</sup> (4 in<sup>2</sup>)
- (2) The current carrying conductors do not exceed 30 in a number.
- (3) The sum of the cross sectional areas of all contained conductors does not exceed 20 percent of the interior cross sectional area of the surface metal raceway.

Example: Based on (44) 90Amp circuits each containing 2 current carrying conductors for a total of 88 current carrying conductors.

# of Raceways =

88 current carrying conductors = 2.9 raceways or three (3) 30 maximum allowable count per raceway

Next test is to see what is the required cross section area of all the conductors inside of the raceway.

With 3 raceways = 88 = 29.33 current carrying conductors  
3  
30 max count per raceway.

However the largest non special order size of Surface Metal Raceway is 4-3/4" x 4" for a total cross sectional area of 19 in<sup>2</sup>, which meets conditions 1 and 2, but what about 3?

Total Area of 30 circuits where each circuit contains (1)#2THHN (L1 and L2) and (1)#8THHN (GN) inside of (1) 4" x 4-3/4" raceway is 0.2682 in<sup>2</sup>/circuit.

Total Area with 30 circuits inside Surface Metal Raceway

$$0.2682 \text{ in}^2 \times 30 = 8.046 \text{ in}^2$$

Therefore to ensure condition 3 is met the following

$$\frac{8.046 \text{ in}^2}{0.20 \text{ (Max \% fill)}} = 40.23 \text{ in}^2$$

$$\sqrt{40.23 \text{ in}^2} = 6.34 \text{ in}$$

Condition 3 is not met with 4" x 4-3/4", therefore you must go to 6 raceways to use 4-3/4" x 4" raceway.

With 6 raceways = 88 = 14.67 current carrying conductors  
6

14 count per raceway = 7 circuits (L1 and L2) per raceway x number of raceways = only 42 rectifier shelves. The Distributive solutions presented in this paper require 44 rectifier shelves to meet the required 9600Amp DC load, therefore (8) 4-3/4" x 4" raceways are required for this raceway system.

With eight (8) raceways = 12 current carrying conductors in each raceway, this works out very neatly considering the raceways are to be fed by (8) panelboards in the distributive solutions presented in this paper.

Total Area with 12 circuits inside each Surface Metal Raceway

$$0.2682 \text{ in}^2 \times 12 = 3.2184 \text{ in}^2$$

$$\frac{3.2184 \text{ in}^2}{0.20 \text{ (Max \% fill)}} = 16.092 \text{ in}^2$$

$\sqrt{16.092 \text{ in}^2} = 4 \text{ in}$  minimum required for width and depth of surface metal raceway.

For the distributive solutions in this paper, the sizing was based on (8) 4-3/4" x 4" surface metal raceways.

#### F. An Example of Sizing a Complete Circuit.

The Bulk Solution in this paper requires each 200Amp rectifier to have a 25Amp – 480VAC – 3 phase delta feed. The congestion at the top of these bulk power plants' rectifier bays is very tight, therefore it is ideal to bring only 1 conduit into the rectifier bay containing all (7) 25 amp circuits. First size the cable. Because it is less than 100amps circuit, the 60°C column from Table 310.16 Allowable Ampacities of Insulated Conductors Rated 0 Through 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable or Earth (Direct Buried), Based on Ambient Temperature of 30°C (86°F) will be utilized. Because there are more than 3 current carrying conductors in conduit, must use derating factors in table 310.15(B)(2)(a) due to 3 current carrying conductors per circuit (21 per conduit) the 25 amp circuit, must be derated by 0.45 for 21 to 30 current carrying conductors.

This factor is applied to table 310.16 table 60°C column values before selecting conductor size. An example of wire derated due to 21 current carrying conductors in one conduit:

$$\#4 = 70\text{Amps} \times 0.45 = 31.5 \text{ Amps}$$

Where:

70Amps = #4 in 60°C column on Table 310.16

0.45 = derating factor from Table 310.15(B)(2)(a)

The circuit is 480VAC – 3 phase, therefore each circuit requires an L1, L2, L3 and GN.

The equipment ground must be in each run of conduit. Based on Table 250.122 Minimum Sizing Equipment Grounding Conductors For Grounding Raceway and Equipment for a 25Amp circuit use the next highest whole number (value 30Amps = #10).

Cross Section Area of wire per table 5 THHN Type Wire – Chapter 9 NEC 2005

L1 = #4 THHN = 0.0824 in <sup>2</sup> x 7	= 0.5768 in <sup>2</sup>
L2 = #4 THHN = 0.0824 in <sup>2</sup> x 7	= 0.5768 in <sup>2</sup>
L3 = #4 THHN = 0.0824 in <sup>2</sup> x 7	= 0.5768 in <sup>2</sup>
GN=#10THHN = 0.0211 in <sup>2</sup> x 7	<u>= 0.1477 in<sup>2</sup></u>
Total area	= 1.8781 in <sup>2</sup>

Size proper trade size EMT Conduit – Table 4 – Article 358 – Electrical Metal Tubing (EMT) 40% fill column = 2" = 1.342 in<sup>2</sup> and 2-1/2" = 2.343in<sup>2</sup> therefore you must select the next largest trade size for required 40% fill area. Finally, end-users prefer to have a piece of Liquidtight Flexible Metal Conduit (LFMC) for the last 12 to 18" where it connects into the top of the rectifier bay. The allowable area is smaller for LFMC as compared to EMT, so double check before selecting trade size in LFMC. NEC2005 – Chapter 9- Table 4 – Article 350 states the values of 2-1/2" = 1.953in<sup>2</sup> which is greater than the required 1.8781 in<sup>2</sup>. The bulk solution presented in this paper used 3" LFMC for the final 18" of each conduit run. The code does not require (7) GN rather just (1) per conduit in this example, the extra grounds are connect to each rectifier ground landing.

#### V. BULK POWER PLANT SOLUTION

The Bulk offering consists of the largest AH cell in the industry with time proven 20 year class - Flooded Lead Acid Technology tied to a switchmode rectifier power platform that accepts either 208VAC - 3phase or 480VAC - 3 phase. Rectifiers must be ordered to correct voltage prior to assembly.

#### A. Bulk Solution – Plant Calculations

String 4 Hour Rate at 1.88VPC = 631Amps/-48V-4000AH

Total 4 hour Battery Current of Plant = 631 Amps x 16 = 10,096Amps for 4 hours.

Total Capacity per Power Plant = 10,000ADC and 9,600ADC for 4 Hours on Battery to End Voltage 1.88vpc

Total Capacity to Recharge Batteries in 10,000Amp System is approximately 400A = N+2

Total Recharge Time to 100% Capacity After 4 Hours at 631Amp to 42VDC String:

$$AH \text{ out} = (9600 \times 4 \text{ Hours}) = 38,400\text{AH} \text{ at } 38.4\%\text{DOD}$$

$$AH \text{ In} = 100\% \text{ Recharge} = 1.25 \times AH \text{ out} = 48,000\text{AH}$$

Time Required with 400Amp Rectification = 48,000AH / 400A = 120 Hours

#### B. Bulk Solutions - Parts

The total number of actual assemblies for this Bulk Power Plant is 771 with indented bill of materials sometimes adding another 80 items.

The following is a high level Bill of Materials, grouped by the 3 major DC system components:

#### C. Bulk Solution - AC

(8) 400Amp -480VAC – 3 phase Feeders consisting of (16) total runs where each run consists of (1) 3/0THHN (L1, L2, L3, N1 and N2) and (1) 3# THHN (GN) in (1) runs of 2-1/2" EMT – Distances include the following:

2x50', 2x60', 2x60', 2x60', 2x80', 2x80', 2x80' and 2x80'

(8) 400Amp -480VAC – 3 phase Panelboards e/w 200% neutral bars, (1) 400Amp Main and (7) 25Amp – 3phase/3pole Circuit Breakers – 65Kair

(50) 25Amp – 480VAC – 3 Phase Delta Feeders consisting of (8) total runs where each run consists of (7) #4THHN (L1 and L2) and (7) #8 THHN (GN) in (1) run of 2-1/2" EMT and last 12" to 18" in (1) 3" LFMC – Distances include the following:

1x34', 1x31', 1x26', 1x22', 1x34', 1x34', 1x20' and 1x15'

#### D. Bulk Solution - DC Power Plant

(1) 10,000 Amp -48VDC Power Plant

(8) 1, 400 Amp Rectifier Bays

(50) 200Amp -48VDC 480VAC - 25Amp 3 phase input

(1) Main Bay with Controller and data collection interface

(2) 750MCM RHH/RHW – Green – 250' each

(1) Remote Interface Module wired to generator and others.

(4) Supplemental Bays

(16) Primary Cabling Assemblies

(12) Ground Assemblies

(8) DC Lights

(16) 600A Battery Distribution Fuse Boards (BDFB) with 100% of all positions filled with fuses (Distance away from plant: 5 x 70', 6 x 55' and 5 x 45').

(1) 10,000Amp Overhead Copper Buss Assembly

(141) 9/16" x 2" x 10' Gray Aux bar with hardware assembly kits

(17) 36" x 2" x 10' Ladder Rack – Gray Solid Stringer Reinforced Power Rack.

(20) 12" x 2" x 10' Ladder Rack – Gray Solid Stringer

(99) 5/8" x 8' Threaded Rod and covers

(1) 5" x 16' x 150' Steel Stud Wall with 1/2" Drywall exteriors. Wall e/w (1) 6' Double Doors and (8) 40" x40" Cable holes.

#### E. Bulk Solution - Battery

(16) Strings of 24-Lead Acid Flooded 4000AH Cells

(6) 2 tier/2 row – 16' long Battery racks

- (4) 2 tier/1 row – 16' long Battery racks
- (16) Battery Cabling Assemblies
- (10) Ground Assemblies for Battery racks

#### *F. Bulk Solution - Floor Loading*

Total System Weight = Approximately 346,757 Lbs  
 Contact Floor Loading is determined by dividing system weight by the total Power Room area and 16 BDFBs = 491.44 lbs/Ft<sup>2</sup>

#### VI. DISTRIBUTIVE DC PLANT AND AC SOLUTION

The distributive offering consists of two (2) new technologies to telecom applications, with very appealing features including outstanding life in high temperatures and lighter than their lead acid counterparts. Styles offered are either Lithium Metal Polymer (LMP) or Lithium Ion (LI). Finally, rounding out the list of solutions, the VRLA (Valve-Regulated Lead Acid) Technology. All batteries will be tied to a densely packed switchmode rectifier power platform that only accepts either 208AC or 240VAC Single Phase. Due to the Service Entrance being 480VAC – 3 phase, a transformer solution must be introduced for all these distributive solutions. The selection of panelboards, circuit breakers and transformers has already been discussed above, to ensure the equipment is installed properly plus protected as designed.

#### *A. Distributive Solution - Parts*

The total number of actual assemblies for this Bulk Power Plant is 106 with indented bill of materials sometimes adding another 80 items. The following is a high level Bill of Materials, presented by the 3 major DC Power Plant components:

#### *B. Distribution Solutions - AC*

- (8) Transformers from 480VAC Delta - 3 phase to 208VAC Y - 3 phase - 112.5KVA - K-Factor Type = K=30
- (8) 400Amp with 200% Neutrals Feeders from (8) 112.5KVA Transformers consisting of (16) total runs where each run consists of (1) 3/0 THHN (L1, L2, L3, N1 and N2) and (1) #3 THHN (GN) in (1) 2-1/2" EMT – Distances include the following: 8X10'
- (8) 400Amp to Transformer - 480VAC - 3 phase - Delta Configuration Feeders consisting of (16) runs where each run consists of (1) 3/0 THHN (L1, L2 and L3) and (1) #3 THHN (GN) in (2)2" EMT – Distances include the following: 26', 26', 38' 38' 32', 26', 15' and 26'.
- (44) 90Amp from 208V – 3 phase panelboard to Raceway Feeders consisting of (44) runs where each run consists (1) #2 THHN for (L1 and L2) and (1) #8 THHN (GN) in (1) 1" EMT – Distances include the following:  
 $33 \times 10' \text{ and } 11 \times 20'$
- (44) 90Amp 208VAC single phase from Raceway to Rectifier Shelf Feeders consisting of (44) runs where each run consists of (1) #2 THHN (L1 and L2) and (1) #8 THHN (GN) in (1) 1" EMT – Distances include the following: 22 x 10' and 22 x 20'
- (8) Surface Metal Raceways 4-3/4" x 4" – Distances in the following: 160' 160', 160', 180', 240', 260', 260' and 290'

- (8) 400Amp Panelboards e/w 400Amp 208VAC - Y - 3 phase e/w (6) 90Amp 208VAC-2pole - 2single phase - 65K air

(44) 90Amp from Raceway to Rectifier Shelf Feeders consisting of (44) runs where each run consists of (1) #2 THHN for (L1 and L2) and (1) #8 THHN (GN) in (1) 1" EMT – Distances include the following: 33 x 10', 11 x 20' for EMT and the last 12" to 18" will require (1) 1" LFMC to connect to rectifier shelf.

#### *C. Distributive Solution - DC Power Plant*

- (22) -48VDC - 500Amp Power Plant e/w (2) 24 position distribution cabinets and (10) 50Amp Rectifiers
- (44) rectifier shelves -48VDC 250Amp DC – Single AC Input 90Amp – 240VAC – (L1, L2 and GN)
- (44) Battery Collector - Copper Busses
- (1) Data Collector Interface – Mounted inside power plant except for Lithium Ion, where is must be mounted on wall or inside equipment rack.
- (1) Remote Interface Monitor wired to generator
- (1056) Fuse/Breaker kits
- (44) 24"x7' High Seismic Equipment Racks
- (22) DC Lights
- (2) 750MCM RHH/RHW – Green – 250'

#### VII. DISTRIBUTIVE BATTERY SOLUTIONS

##### *A. Lithium Metal Polymer (LMP) Option*

###### 1. Calculations

Battery Current Maximum to Support a 436.36A Plant Load  
 Total 4 Hour Load at 1.75VPC = 18.7Amps/-48V-80AH Unit  
 Total 4 Hour Battery Current per Power Plant = 18.7Amp x 24 units = 448.80Amp to 1.75VPC/42VDC – 24xunit=battery

Total Capacity to Recharge Batteries in 500Amp System is approximately 50A = N+1 Standards  
 Total Recharge Time to 100% Capacity After 4 Hours at 9600Amp Total System/436.4 Amp/Plant to 42VDC Module at 77°F:  
 $\text{AH out} = 9600 \times 4 \text{ Hours} = 38,400\text{AH}$  Battery /22 plants = 1745.5AH/plant at 91% DOD.  
 $\text{AH In} = 100\% \text{ Recharge} = 1.25 \times \text{AH out} = 2181.8\text{AH}$   
 Time Required with 50Amp Rectification with 30Amp Breaker installed =  $2181.8\text{AH} / 50\text{A} = 43.63 \text{ Hours}$

###### 2. Distributive Solution – LMP Battery Plant

- (530) 48V – 80AH – Lithium Metal Polymer Units
- (265) Battery Shelves with spacers
- (530) #10 RHH/RHW Battery Wire Harness (24) per power plant each consisting of (7' x 24 for returns and 7'x24 for loads)
- (530) 30Amp Battery Disconnects

###### 3. Distributive Solution – LMP Floor Loading

Total System Weight = Approximately 79,081 Lbs  
 Total weight divided by the total of power plants, then divide Power Plant weight by the contact floor area of each Power Plant area = 328.95lbs/Ft<sup>2</sup>

## *B. Lithium-Ion (LI) Option*

### 1. Calculations

Battery Current Available to Support a 436.36Amp Plant Load

Total 4 Hour Load at 2.625V/cell cutoff = 12.19Amps/-48V-50AH Unit

Total Capacity per Power Plant = 12.19Amp x 36 units = 438.84Amp to 2.625V/cell cutoff

Total Capacity to recharge Batteries in 500Amp System is approximately 50A = N+1 Standards

Total Recharge Time to 100% Capacity after 4 Hours at 9600Amp Total System/436.4 Amp/Plant to 42VDC Module at 77°F

AH out = 9600 x 4 Hours = 38,400AH Battery/22 plants = 1745.5AH/plant at 97% DOD.

AH In = 100% Recharge = 1.25 x AH out = 2181.8AH

Time Required with 50Amp Rectification = 2181.8AH/50A = 43.64 Hours

### 2. Distributive Solution – LI Battery Plant

(792) 48V – 50AH – Lithium Ion Units

(792) #10 RHH/RHW Battery Wire Harness (36) per power plant each consisting of (7' x 24 for returns and 7'x24 for loads)

(792) 20 Amp Battery Disconnects

### 3. Distributive Solution – LI Floor Loading:

Total System Weight = Approximately 85,652Lbs

Total weight divided by the total of power plants, then divide Power Plant weight by the contact floor area of each Power Plant area = 366.29 lbs/Ft<sup>2</sup>

## *C. Valve-Regulated Lead Acid (VRLA) Option*

### 1. Calculations

Battery Current Maximum to Support a 436.36A Plant Load

Total 4 Hour Load at 1.75VPC = 135.6Amps/-12V-150AH Unit

Total 4 hour Battery Current per Power Plant = 135.6Amp x 4 strings = 542.4Amp to 1.75VPC/42VDC plant

Total Capacity to Recharge Batteries in 500Amp System is approximately 50A = N+1 Standards

Total Recharge Time to 100% Capacity After 4 Hours at 9600Amp Total System/436.4 Amp/Plant to 42VDC Module at 77F:

AH out = 9600 x 4 Hours = 38,400AH Battery /22 plants = 1745.5AH/plant at 72.7% DOD

AH In = 100% Recharge = 1.25 x AH out = 2181.8AH

Time Required with 50Amp Rectification = 2181.8AH / 50A = 43.63 Hours

### 2. Distributive Solution – VRLA Battery Plant

(352) 48V – 150AH – 12V- Valve Regulated Lead Acid Units

(88) Battery Shelves with spacers

(88) 3/0 RHH/RHW Battery Wire Harness (24) per power plant each consisting of (7' x 24 for returns and 7'x24 for loads)

(88) 200 Amp Battery Disconnects

### 3. Distributive Solution – VRLA Floor Loading:

Total System Weight = Approximately 83,707 Lbs

Total weight divided by the total of power plants, then divide Power Plant weight by the contact floor area of each Power Plant area = 355.24 lbs/Ft<sup>2</sup>

## VII. FIRM PRICE QUOTES

A. The following Firm Price Quotes, detailed drawings and Cost by phase with gross margin calculations are offered for each proposed solution. All quotes were prepared using the same gross margin of approximately 18.22%, Full Time Equivalent (EFT) Crew size of 3.63 working standard hours – no overtime. Installation pricing includes all per diem, transportation and air costs with deployment of crews to Anywhere Continental United States of America.

B. Quotes were prepared utilizing the model of the EF&I Vendor ordering the materials directly into the end-user's procurement system with materials shipping to end-user's specified logistic center. No materials pricing is offered direct from the EF&I Vendor in any of these examples to keep all thing equal; however it is a normal practice to charge approximately 5 to 10% of the total material cost to account for all missed items during installation. On firm price quotations, this is viewed as an insurance policy to protect against change orders.

C. Logistic Services, also known as freight, is a cost that typically runs around 12% to 25% of the total material cost budget. For this paper, the Logistic Services portion on quotes is based on 15% of total for end-user logistic services budget to get materials from supplier to end-user's specified location. The EF&I vendor for logistic services in these examples is based on 8% of total material budget. This 8% is to cover any inside delivery and expedited shipments which seem to always occur on these large projects. End-users should ensure all competitive quotes from EF&I vendors have total Freight Cost broken out in a separate line item to ensure quotes are apples to apples. No one ships for FREE!

E. The BULK offering consists of Figure 1, Figure 2, and Figure 3. The quote is prepared on Table 1A and cost by phase with GM is on Table 1B.

F. The Distributive Solution with Lithium Metal Polymer offering can be seen on Figure 4 and Figure 5. The quote is prepared on Table 2A and the cost by phase with GM is on Table 2B.

G. The Distributive Solution with Lithium Ion offering consists of Figure 4, Figure 6 and Figure 6a. The quote is prepared on Table 3A and the cost by phase with GM is on Table 3B only is on Figure 6 option only. Figure 6a is presented without any tables.

H. The Distributive Solution with Valve Regulated Lead Acid offering consists of Figure 4 and Figure 7. The quote is prepared on Table 4A and the cost by phase with GM is on Table 4B.

## VIII. CONCLUSIONS

TABLE 6  
SUMMARY OF SOLUTIONS

Description	Bulk-Wet	Dist-LMP	Dist-LI	Dist-VRLA
Start Date	9-12-06	9-12-06	9-12-06	9-12-06
Finish Date	11-2-07	5-14-07	5-17-07	3-12-07
# of Install Hours	5830.76	3008.34	3061.14	1917.14
End-User Total Material and Logistic Cost	\$1.48 MM	\$2.22 MM	\$2.10 MM	\$0.56 MM
Total E&I Price from EF&I Vendor	\$0.56 MM	\$0.42 MM	\$0.42 MM	\$0.21 MM
Total Solution Price	\$2.04 MM	\$2.64 MM	\$2.52 MM	\$0.77 MM
Total AC Weight	13,070 lbs	21,185 lbs	21,185 lbs	21,185 lbs
Total Power Plant(s) Weight	47,957 lbs	10,604 lbs	10,604 lbs	10,604 lbs
Total Battery Weight	285,730 lbs	47,292 lbs	53,862 lbs	51,917 lbs
Total Solution Weight	346,757 lbs	79,081 lbs	85,652 lbs	83,707 Lbs
Total Power Plant Contact Floor Loading	491.44 lbs/ft <sup>2</sup>	328.95 lbs/ft <sup>2</sup>	366.29 lbs/ft <sup>2</sup>	355.24 lbs/ft <sup>2</sup>
Total Area	679 ft <sup>2</sup>	248 ft <sup>2</sup>	248 ft <sup>2</sup>	248 ft <sup>2</sup>
Difference from Bulk Area	n/a	431 ft <sup>2</sup>	431 ft <sup>2</sup>	431 ft <sup>2</sup>
Maximum Racks # of Rack (4ft <sup>2</sup> )	n/a	107	107	107

Where:

MM = 000,000

Full Weights, Areas and # of Equipment racks can be found in Table 5.

## IX. ANALYSIS OF SOLUTIONS

A. The most space effective solution for this paper problem of 9600Amps for 4 hour protection time and fitting the most revenue producing equipment racks is any of the Distributive Solutions. Approximately 107 (2'x2') Equipment racks could be gained by installing a Distributive Power Plant to the Bulk Power Plant solution. If the Service Entrance was 208VAC, the number of racks could increase to 125, due to space freed up with no transformers.

B. The most cost effective solution considering all the design restrictions is the Distributive Solution with VRLA option. The pricing is too good to ignore this option. While it is clear that the Lithium Metal Polymer is by far the lightest solution offered in the paper; the cost per unit/module is extremely expensive for only gaining 26.29 Lbs/Ft<sup>2</sup> over the VRLA technology option to meet the design load. If this weight difference does make the floor loading unsafe, one recommendation to save end-user's valuable capital is to buy the VRLA and put down a steel plate of the correct thickness and distribute the weight over a larger area, thus reducing contact floor loading. The end-user's performance bonus should see a healthy increase, if actual battery costs for DC Power Plants are the VRLA and they budgeted for the Lithium Technology. VRLA solutions also would be ready for service the fastest of any of the solutions offered in this paper.

C. The distributive architecture makes sense if you want to grow modularly for a smaller initial DC Amp load or jump into a large load like the one presented in this paper.

D. The Valve Regulated Lead Acid (VRLA) Technology could be changed out approximately 2 times with labor and freight included, over a 10 year span, and still would be less than the initial cost of the Lithium Technologies at present pricing levels. With the high cost of capital, there is no reason not to use the VRLA, except in high temperature situations or areas where end-users have to wear snow shoes to walk around the equipment room, due to such poor building floor loading.

E. The differences between Bulk and Distributive can increase with a Service Entrance of 208VAC – 3 phase, where no transformers are required. This condition will also reduce the distributive solution's contact floor loading. AC pricing will also go down on the distributive solutions with a service entrance of 208VAC – 3phase or 240VAC – single phase by approximately \$4600/per 500Amp -48VDC Power Plant in groups of three (3), due to the price of copper wound transformers to step down from 480VAC to 208VAC.

F. If there is a need for distribution larger than 100amp from one of these distributive architecture solutions, it would be optimal to put in a true "A" Plant-Black and "B" Plant-Blue with special distribution to handle the large size breaker/fuses. The pricing for this type of customization is

not expensive considering the total dollar value for a project of this size.

G. Current Carrying Conductors that are not sized correctly will generate a great deal of heat, due to missed sizing practices based on the wire type jacket temperature rating instead of the load temperature rating. For a 40Amp - 3 phase circuit operating at approximately 200ft from load center. Going from wire size #8 to #6, the estimated heat generation improvement is 285 watts per circuit or 973 BTU/hr. Keep your Cool!

H. The Lithium Technology is very limited for higher rate discharges and as a result more units in parallel are needed for these solutions to match the performance of VRLA. Both the Lithium Technology products presented in this paper according to their manufacturer's specification sheet have maximum discharge current rates equal to, in some cases, the 4 hour rate. These products also go down to a much lower Depth of Discharge (DOD%) compared to the VRLA and Flooded Technologies. While this deep discharge is not a problem, considering the rate available for each Lithium unit and the number of paralleled modules/units, exact length battery wiring harnesses should be used to ensure uniform sharing of current during discharge and charge.

I. For this paper's problem set, the optimal solution would be the Distributive architecture tied to Valve – Regulated Lead Acid Units. OEM Battery Manufacturers of these VRLA products might want to start marketing this product not as Valve Regulated Lead Acid but **Value** Regulated Lead Acid against the new options available.

J. For sites without a generator, now requiring 8 hours of battery protection time for the same -48VDC 9600 amp load, both the distributive and bulk solutions would require additional racks and strings/units of batteries.

K. Power Plant and/or Rectifier Manufacturer's should start to publish their rectifiers full load input AC current for full load DC output. This practice will provide end-users and EF&I vendors with a more accurate way to design and size the AC distribution required to feed these power plants.

L. The smart technology "LED Indicator" associated with the Lithium Products is something the VRLA products will probably not have any time soon. Therefore to satisfy this end-user requirement, it is recommended to tie a 200Amp/200mv shunt, one for each string, to the Battery Load Collector Buss at the top of one of the Distributive Power Plant's equipment racks. With the shunt(s) installed, an off the shelf centralized data collector interface could be utilized and wired to each of the distributive plant's shunts. This solution would alarm end-users when their VRLA products are moving into the trouble zone based on actual string current % change from baseline.

M. End-users should write into their RFQs for VRLA units that the Battery OEMs provide the baseline for each unit/module's impedance and standard new product float current. Once the troubled string is identified, check all individual actual impedance measurements vs. initial values as originally installed to determine which units have moved a large % away from baseline.[6][7][8] Any units with high % actual impedance away from the baseline impedance as provided by the OEM should be changed out.

N. The following should be incorporated into end-user's VRLA RFQs, where 99.999% reliability is desired. This criteria will ensure end-users get the full protection time as designed:

1. If a 4 unit VRLA string is less than 50% expected life and contains more than 75% troubled units, all troubled units can be replaced, mixing old with new units.
2. If a 4 unit VRLA string is over 50% expected life and contains more than 50% troubled units, the entire string should be changed out.
3. If a 4 unit VRLA string is over 80% expected life and contains more than 25% troubled units, the entire string should be changed out.

O. End-users, to protect their battery investments, should write into their RFQs that the EF&I Vendor must turn over all baseline units measurements. End-user's battery installation RFQs should request a front equipment drawing similar to the figures 5, 6, 7 presented in this paper, showing how these products are actually installed and labeled to ensure baseline measurement match apples to apples for the life of the system.

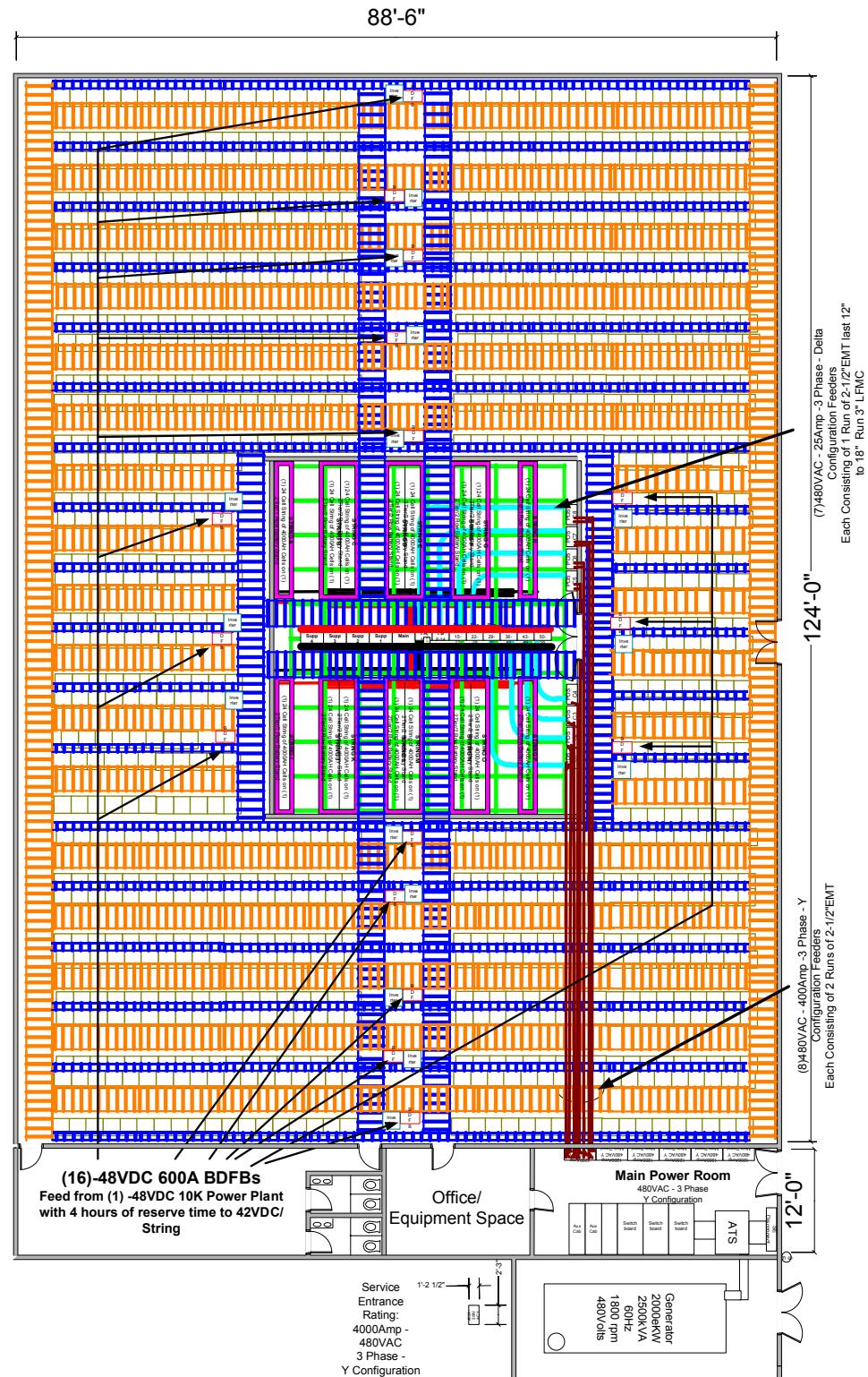
P. End-users may want to consider writing into their next VRLA RFQs, that the VRLA's warranty duration must be either 5, 10, 15 or 20 years FULL, including all installation in and out costs, removal of spent batteries, proof of spent batteries recycling certification, all installation performed to the end-user's specification for maintenance windows. The OEMs can essentially take the end-users out of the battery business, simply by maintaining the end-user's battery systems, the same ones they manufactured. While this practice will add up-front cost to the VRLA unit, it will protect the end-user's battery protection time, making their lives a little easier. Plus it will provide a very competitive RFQ platform, if you believe the theoretical life expectancy of the Lithium Technologies for telecom applications operating at 77°F(25°C). At this writing, the Lithium Technologies have no actual baseline for life expectancy with any end-users.

## X. ACKNOWLEDGEMENT

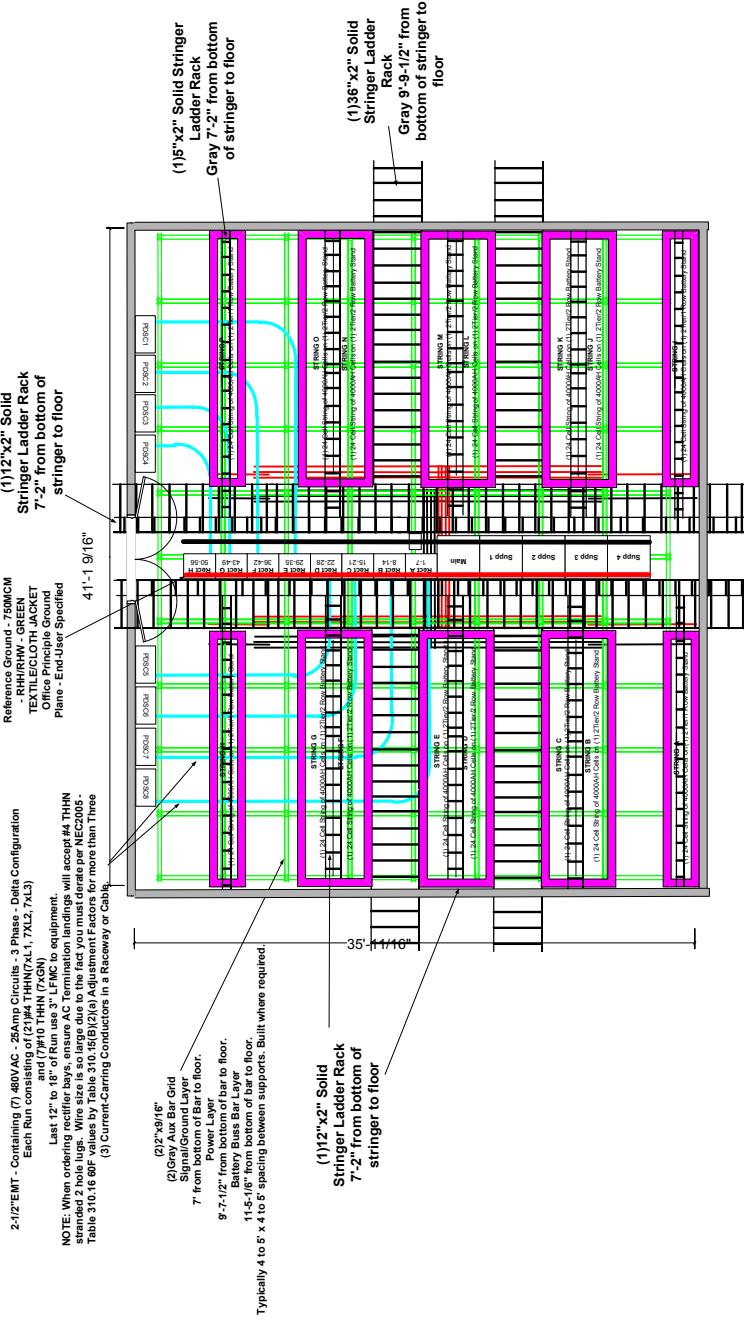
Gregg Tsuchimoto, now with DC Pro, former Director of Engineering and General Manager at USI, for proofing and checking of my work. Gregg is a true all star at engineering and designing these Distributive and/or Bulk DC Power Plant solutions.

## XI. REFERENCES

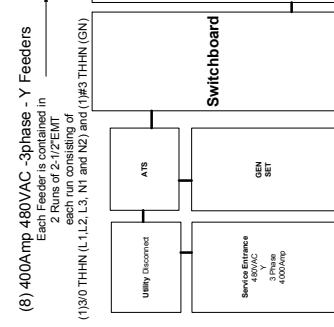
- [1] Telecordia GR-1275 Generic Requirements for Installation of a Telecommunications Central Office Installation.
- [2] Telecordia GR-1502 Generic Requirements for Engineering of a Telecommunications Central Office Installation.
- [3] Generic Requirements from Telecommunications Service Providers.
- [4] National Electrical Code (NEC) 2005
- [5] R. Author and R. A. Shanahan-PE, "Neutral Currents in Three Phase Wye Systems" Square D – August 1996.
- [6] M. R. Moore, "Real-Time Expected Life and Capacity on VRLA and Flooded Products. Unraveling the Predicting Code" – Intelec 2004 Proceedings – 2004 – pp 661-670.
- [7] R. Z. Toll and M. R. Moore, "Real-Time Expected Life on VRLA products: A customer's [End-User] Perspective", Intelec 2002 Proceedings, pp 115-120.
- [8] M. R. Moore, F. L. Tarantino, F. J. Chiacchio, and J. R. Resurreccion, "Real-Time Expected Life on VRLA Products: A Manufacturer's Perspective", Intelec 1995 proceedings, pp 65-69.



**The Bulk Equipment Room**  
**Figure 1**



**The Bulk DC Power Room**  
**Figure 2**



Show here coming from just (1) 1200Amp Panelboard to fit page while more can capable to meet the load it's good electrical practice to spread this out load across two or three panelboards to minimize chance entire system goes down.

#### (7) 25Amp 480VAC -3phase - Delta Feeders

All Feeders are contained in

1 Run of 2-1/2"EMT

(21) #4 THHN (7xL1,7xL2, 7xL3) and (7) #10 THHN (7xGN)

Last (12 to 18") of run use 3" LFMC to equipment.

**NOTE:** When ordering rectifier bays, ensure AC termination landings will accept #4 THHN stranded 2 hole lugs. Wire size is so large due to the fact you must Derate NEC2005 - Table 310.16 values by Table 310.15(B)(2)(a) Adjustment Factors or for more than Three Current-Carrying Conductors in a Raceway or Cable.

#### Primary Cabling Connections

At the Power Plant Side to Feed BDFB USE NARROW TONGUE LUGS ONLY

Cable Hole  
Must be gaged with the above materials

Insulators.

5/8" Threaded Rod and Gray Cover

File Ends and Paint

5/8" Ladder Rack - Gray for 2T Bar/Bow

12" x 2" Ladder Rack - Gray for 2T Bar/Bow

P x 2" 16" Gray Air Bar

File Ends and Paint Gray

5/8" Threaded Rod

File Ends and Paint

5/8" Ladder Rack - Gray for 2T Bar/Bow

12" x 2" Ladder Rack - Gray for 2T Bar/Bow

P x 2" 16" Gray Air Bar

File Ends and Paint

5/8" Threaded Rod

File Ends and Paint

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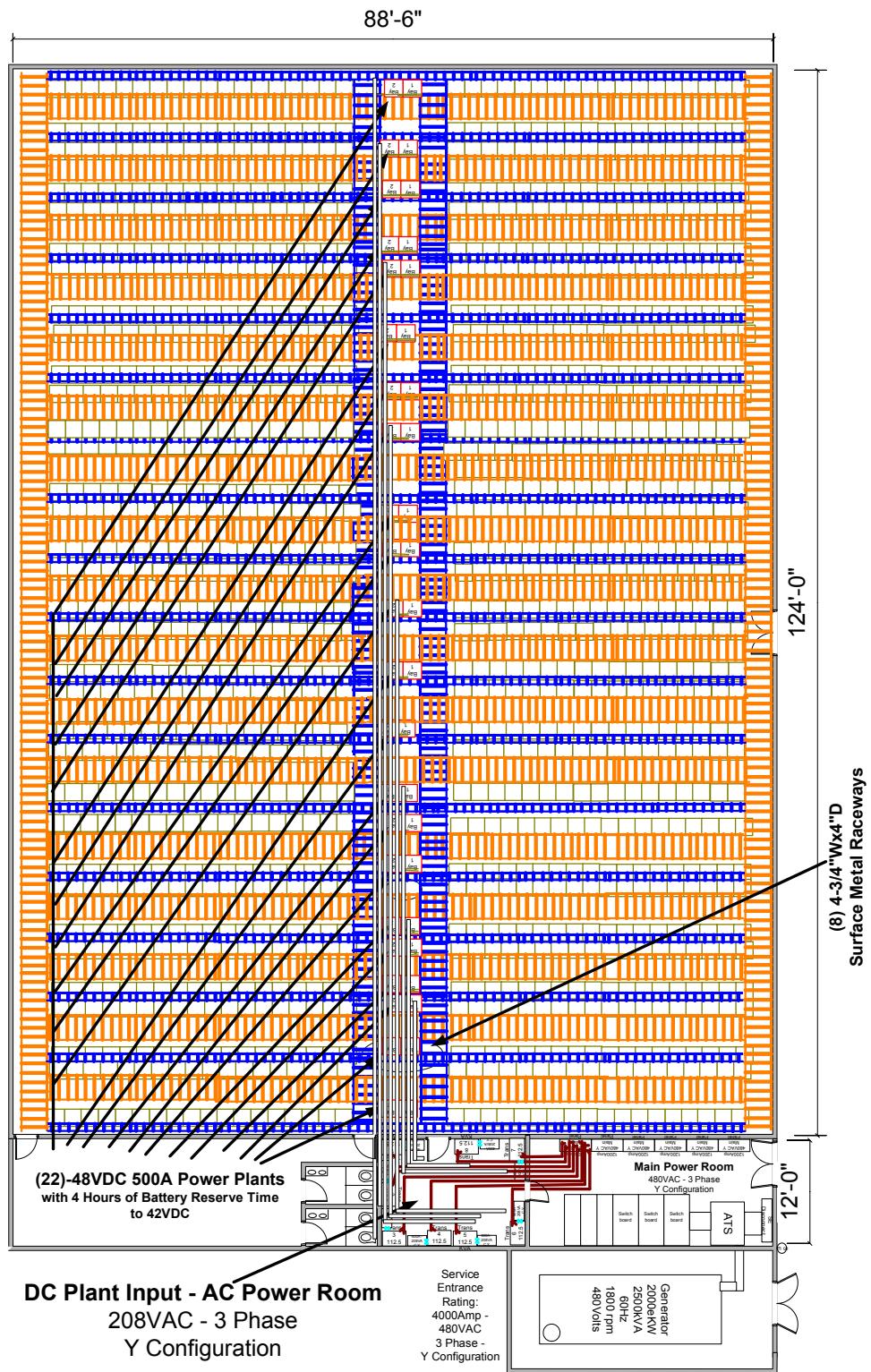
File Ends and Paint

5/8" Threaded Rod</

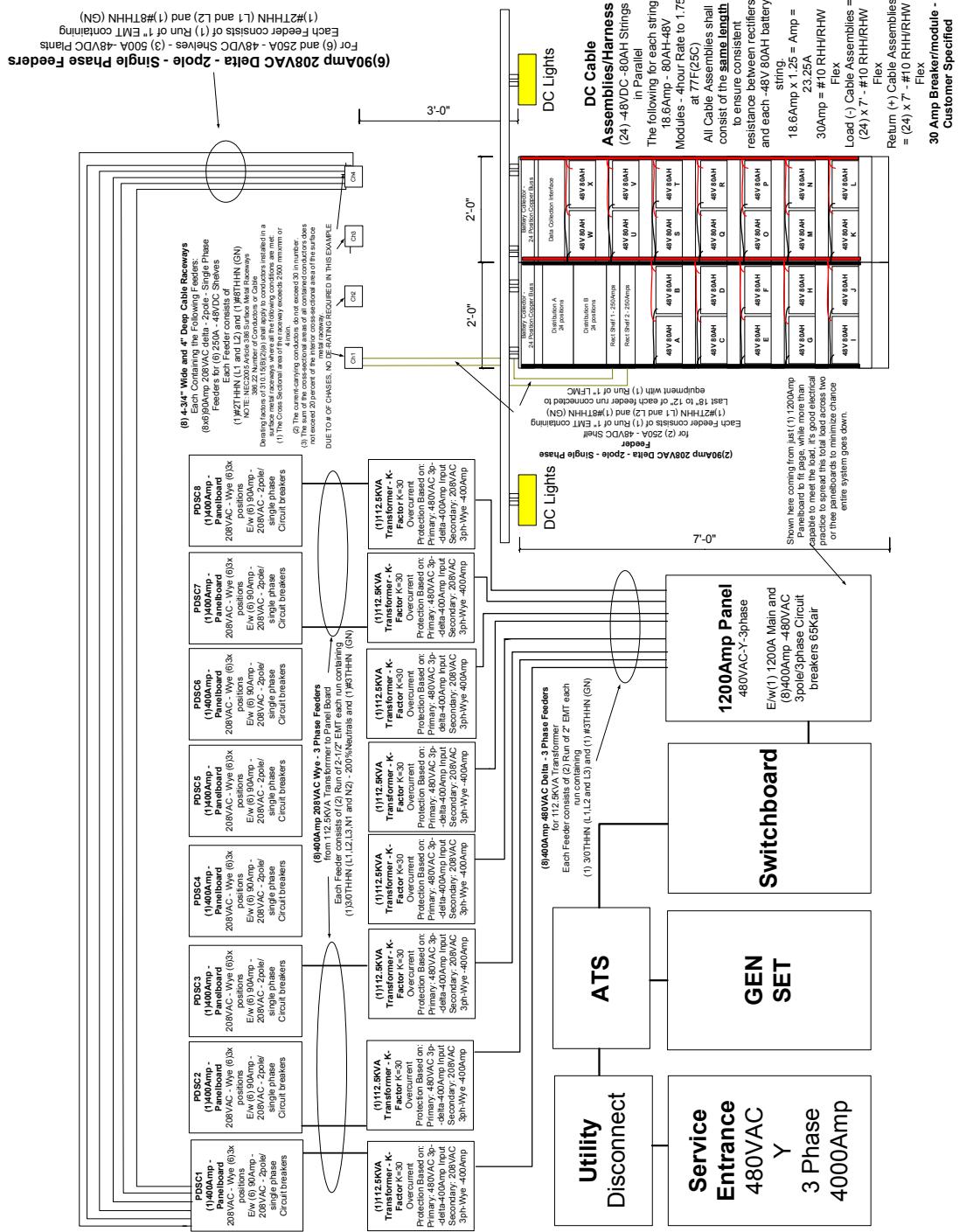
Table 1A

FIRM PRICE QUOTATION									
<u>QUOTE NO.:</u> 06202006-0926-MM			<u>QUOTE DATE:</u> June 20, 2006 <u>PREPARED BY:</u>						
<b>RFQ#</b> <i>Quote To:</i>	<b>THE BULK - (1)10K AmpDC -48 with (16)600A BDFBs and (16)24 Flooded Lead Acid 4K AH Cells</b> <b>Ma and Pa TELECOM COMPANY</b> <b>Pa Customer</b> <b>1313 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 333-444-5555 Cell 444-999-2222</b> <b>pa.customer@telecom-company.com</b>								
	<i>Project Site:</i>	<b>Ma and Pa TELECOM COMPANY</b> <b>Ma Customer</b> <b>1314 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 444-555-2222 Cell 444-999-2222</b> <b>ma.customer@telecom-company.com</b>							
<u>TERMS:</u> 30 Days Net									
<u>PRICES VALID FOR:</u> 30 Days									
<u>PO REQUIRED:</u> To Proceed									
Item	Qty	Est.	P/N	Description			Unit Cost	Amount	
<b>I</b>	1	Est.	C-F	<b>Customer Supplied - Furnishment of Materials (C-MA)</b> <i>Invoiced upon written acceptance of engineering package</i>			\$ 1,288,148	\$ 1,288,148	
				Start: 12-Sep-06	Breakout Pricing	Power Room			Secondary Space
				Add Material	\$ 1,065,703	\$ 222,445			-
				Maintenance Material	\$ -	\$ -			-
<b>II</b>	1	Est.	C-LS	<b>Customer Supplied - Logistic Services (C-LS) to Specified Logistic Center</b> <i>Vendor will order materials to ship to end-user's Logistic Center</i>			\$ 193,222	\$ 193,222	
				Start: 25-Dec-06	Breakout Pricing	Power Room			Secondary Space
				Finish: 25-Dec-06	Add Material	\$ -			\$ -
				Removal/Salvage Material	\$ -	\$ -			-
<b>A.</b>	1	Est.	E	<b>Factory Direct Engineering Services (EN)</b> <i>Invoiced upon written acceptance of engineering package</i>			\$ 66,208	\$ 66,208	
				Start: 12-Sep-06	Breakout Pricing	Power Room			Secondary Space
				Add Labor	\$ 22,319	\$ 43,889			-
				Maintenance Labor	\$ -	\$ -			-
<b>B.</b>	1	Est.	F	<b>Furnishment of Materials (MA)</b> <i>Invoiced at project start</i>			\$ -	\$ -	
				Start: -	Breakout Pricing	Total Project			
				Finish: 25-Dec-06	Materials	\$ -			-
				Transportation Charges	\$ -	\$ -			-
<b>C.</b>	1	Est.	LS	<b>Logistic Services (LS)</b> <i>Invoiced upon materials receipt at project site. - Freight: Bestway</i>			\$ 103,052	\$ 103,052	
				Start: 15-Sep-06	Warehousing Charges	\$ -			-
				Finish: 29-Jan-07	Transportation Charges	\$ -			\$ 103,052
				Inside Delivery	\$ -	\$ -			-
<b>D.</b>	1	Est.	I	<b>Factory Direct Field Services (FS)</b> <i>Invoiced upon written acceptance of job completion</i>			\$ 400,717	\$ 400,717	
				Start: 29-Jan-07	Breakout Pricing	Power Room			Secondary Space
				Add Labor	\$ 135,086	\$ 265,631			-
				Maintenance Labor	\$ -	\$ -			-
<b>***Quoted Project Start Date (No Later Than):</b>				<b>September 12, 2006</b>			<b>SUB TOTAL:</b>	\$ 569,977	
<b>****Quoted Project 100% Completion Date (Ready For Service):</b>				<b>November 2, 2007</b>			<b>* TAXES:</b>	See Notes	
							<b>** QUOTE TOTAL:</b>	<b>\$ 569,977</b>	

Table 1B



**The Distributive  
Equipment Room**  
**Figure 4**



## The Distributive Solution with Lithium Metal Polymer Option

Figure 5

Table 2A

FIRM PRICE QUOTATION									
<b>QUOTE NO.:</b> 06202006-2215-MM <input style="width: 100px; height: 20px;" type="button" value="Print"/>					<b>QUOTE DATE:</b> June 20, 2006 <b>PREPARED BY:</b> <input style="width: 100px; height: 20px;" type="button" value="Print"/>				
<b>RFQ#</b>		(22) 500Amp -48VDC e/w (10)50A PCUs and (24)48V80AH LMP Units							
<b>Quote To:</b>		<b>Ma and Pa Telecom Company</b> <b>Pa Customer</b> <b>1313 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 333-444-5555 Cell 444-999-2222</b> <b>pa.customer@telecom-company.com</b>							
		<b>Ma and Pa Telecom Company</b> <b>Ma Customer</b> <b>1314 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 444-555-2222 Cell 444-999-2222</b> <b>ma.customer@telecom-company.com</b>							
<b>Project Site:</b>		<b>TERMS:</b> 30 Days Net <b>PRICES VALID FOR:</b> 30 Days <b>PO REQUIRED:</b> To Proceed							
Item	Qty	Est.	P/N	Description				Unit Cost	Amount
<b>I</b>	1	Est.	C-F	<b>Customer Supplied - Furnishment of Materials (C-MA)</b> <i>EF&amp; Vendor orders directly into Customer's Procurement System</i>				\$ 1,933,556	\$ 1,933,556
	<b>Start:</b> 12-Sep-06		Breakout Pricing		Power Room	Secondary Space			
			Add Material	\$ 1,822,331	\$ 111,225				
			Maintenance Material	\$ -	\$ -				
<b>II</b>	1	Est.	C-LS	<b>Customer Supplied - Logistic Services (C-LS) to End-User's Logistic Center</b> <i>EF&amp; Vendor will order materials to ship to End-User's Logistic Center</i>				\$ 290,033	\$ 290,033
	<b>Start:</b> 21-Nov-06		Breakout Pricing		Power Room	Secondary Space			
Finish:			21-Nov-06	Transportation Charges	\$ 290,033				
<b>A.</b>	1	Est.	E	<b>Factory Direct Engineering Services (EN)</b> <i>Invoiced upon written acceptance of engineering package</i>				\$ 37,568	\$ 37,568
	<b>Start:</b> 12-Sep-06		Breakout Pricing		Power Room	Secondary Space			
			Add Labor	\$ 35,930	\$ 1,638				
			Maintenance Labor	\$ -	\$ -				
<b>B.</b>	1	Est.	F	<b>Furnishment of Materials (MA)</b> <i>Invoiced at project start</i>				\$ -	\$ -
	<b>Start:</b> -		Breakout Pricing		Total Project				
Finish:			21-Nov-06	Materials	\$ -				
<b>C.</b>	1	Est.	LS	<b>Logistic Services (LS)</b> <i>Invoiced upon materials receipt at project site. - Freight: Bestway</i>				\$ 154,685	\$ 154,685
	<b>Start:</b> 14-Sep-06		Breakout Pricing		Total Project				
			Warehousing Charges	\$ -	-				
			Transportation Charges	\$ 154,685	-				
<b>D.</b>	1	Est.	I	<b>Factory Direct Field Services (FS)</b> <i>Invoiced upon written acceptance of job completion</i>				\$ 234,992	\$ 234,992
	<b>Start:</b> 22-Dec-06		Breakout Pricing		Power Room	Secondary Space			
			Add Labor	\$ 224,749	\$ 10,243				
			Maintenance Labor	\$ -	\$ -				
			Finish:	14-May-07	Removal/Salvage Labor	\$ -	\$ -		
Transitions/Moves Labor	\$ -	\$ -							
Outsourced Services [Subs]	\$ -	\$ -							
<b>***Quoted Project Start Date (No Later Than):</b>				<b>September 12, 2006</b>				<b>SUB TOTAL:</b>	\$ 427,245
<b>****Quoted Project 100% Completion Date (Ready For Service):</b>				<b>May 14, 2007</b>				<b>* TAXES:</b>	See Notes
								<b>** QUOTE TOTAL:</b>	\$ 427,245

Table 2A

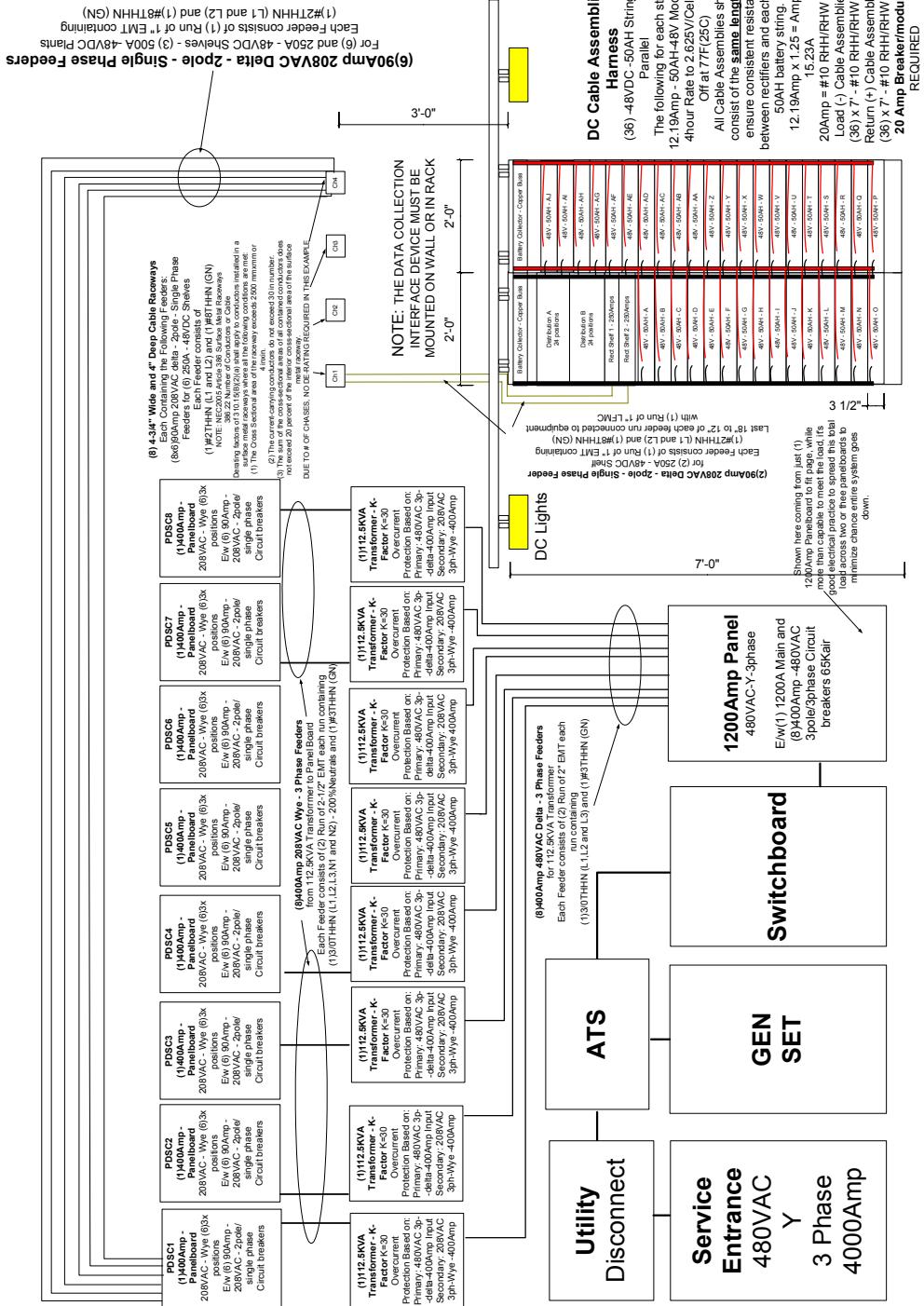
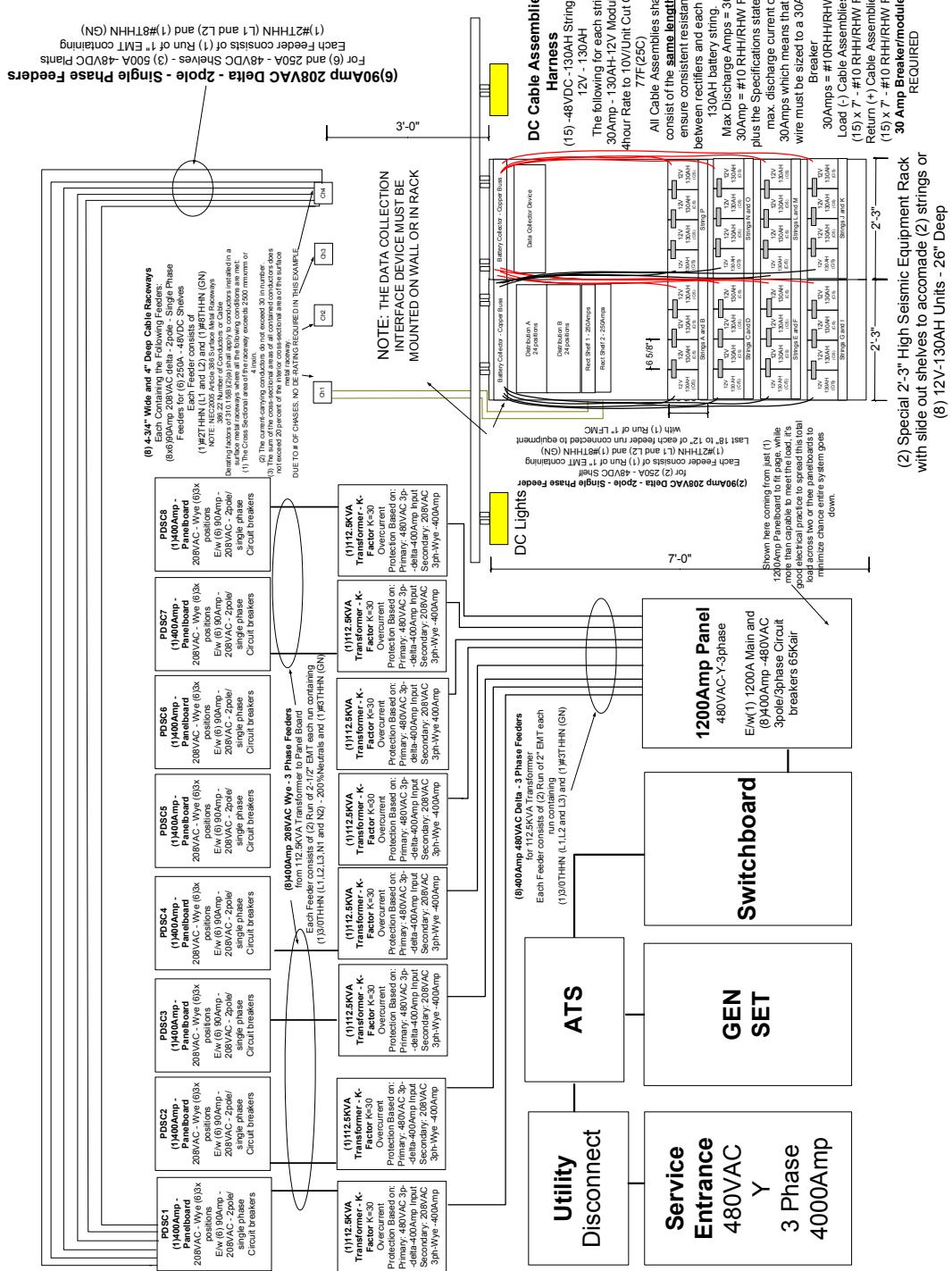


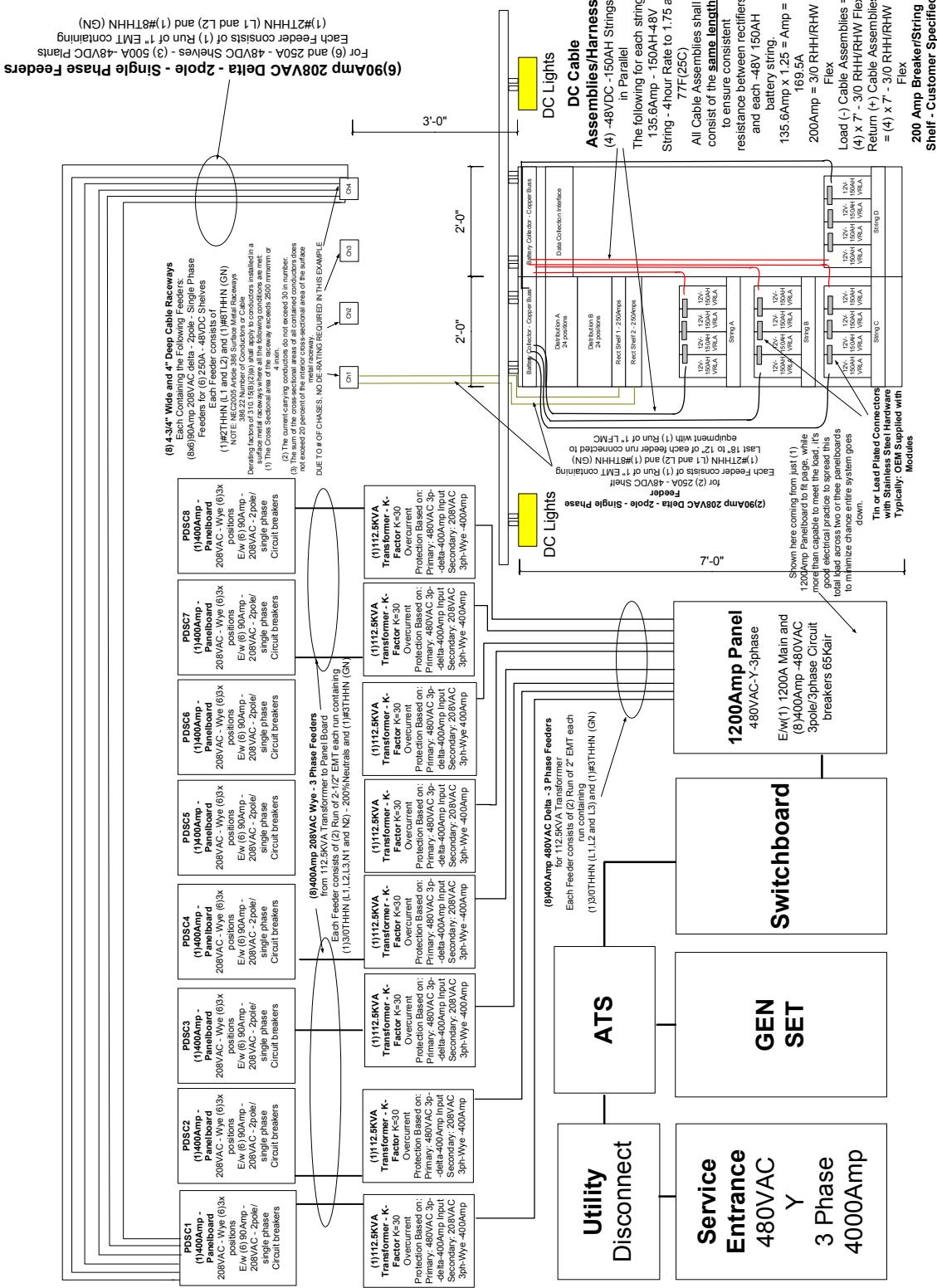
Table 3A

FIRM PRICE QUOTATION							
<b>QUOTE NO.:</b> 06202006-2215-MM <input type="text"/>			<b>QUOTE DATE:</b> June 20, 2006 <b>PREPARED BY:</b> <input type="text"/>				
Quote To:	<b>RFQ#</b> (22) 500Amp -48VDC e/w (10)50A PCUs and (36)-48VDC - 50AH Lithium Ion Modules <b>Ma and Pa Telecom Company</b> <b>Pa Customer</b> <b>1313 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 333-444-5555 Cell 444-999-2222</b> <b>pa.customer@telecom-company.com</b>						
	Project Site:	<b>Ma and Pa Telecom Company</b> <b>Ma Customer</b> <b>1314 Mockingbird Lane</b> <b>Jamestown IN</b> <b>Ph 444-555-2222 Cell 444-999-2222</b> <b>ma.customer@telecom-company.com</b>					
<b>TERMS:</b> 30 Days Net <b>PRICES VALID FOR:</b> 30 Days <b>PO REQUIRED:</b> To Proceed							
Item	Qty	Est.	P/N	Description		Unit Cost	Amount
I	1	Est.	C-F	<b>Customer Supplied - Furnishment of Materials (C-MA)</b> <i>EF&amp;I Vendor orders directly into Customer's Procurement System</i>		\$ 1,830,596	\$ 1,830,596
	Start: 12-Sep-06		Breakout Pricing	Power Room	Secondary Space		
			Add Material	\$ 1,719,371	\$ 111,225		
			Maintenance Material	\$ -	\$ -		
II	1	Est.	C-LS	<b>Customer Supplied - Logistic Services (C-LS) to End-users Logistic Center</b> <i>EF&amp;I Vendor will order materials to ship to End-user's Logistic Center</i>		\$ 274,589	\$ 274,589
	Start: 22-Nov-06		Breakout Pricing	Power Room	Secondary Space		
			Transportation Charges	\$ -	\$ 274,589		
			Finish: 22-Dec-06				
A.	1	Est.	E	<b>Factory Direct Engineering Services (EN)</b> <i>Invoiced upon written acceptance of engineering package</i>		\$ 38,060	\$ 38,060
	Start: 12-Sep-06		Breakout Pricing	Power Room	Secondary Space		
			Add Labor	\$ 36,430	\$ 1,630		
			Maintenance Labor	\$ -	\$ -		
B.	1	Est.	F	<b>Furnishment of Materials (MA)</b> <i>Invoiced at project start</i>		\$ -	\$ -
	Start: -		Breakout Pricing	Total Project			
			Materials	\$ -			
			Finish: 22-Nov-06				
C.	1	Est.	LS	<b>Logistic Services (LS)</b> <i>Invoiced upon materials receipt at project site. - Freight: Bestway</i>		\$ 146,448	\$ 146,448
	Start: 14-Sep-06		Warehousing Charges	\$ -			
			Transportation Charges	\$ -	\$ 146,448		
			Inside Delivery	\$ -			
D.	1	Est.	I	<b>Factory Direct Field Services (FS)</b> <i>Invoiced upon written acceptance of job completion</i>		\$ 236,681	\$ 236,681
	Start: 25-Dec-06		Breakout Pricing	Power Room	Secondary Space		
			Add Labor	\$ 226,543	\$ 10,138		
			Maintenance Labor	\$ -	\$ -		
			Removal/Salvage Labor	\$ -	\$ -		
<b>***Quoted Project Start Date (No Later Than):</b> <span style="color: green;">September 12, 2006</span>						<b>SUB TOTAL:</b>	\$ 421,189
<b>****Quoted Project 100% Completion Date (Ready For Service):</b> <span style="color: red;">May 17, 2007</span>						<b>* TAXES:</b>	See Notes
						<b>** QUOTE TOTAL:</b>	\$ 421,189

Table 3B



## The Distributive Solutions - Lithium Ion Option II Figure 6a



## The Distributive Solutions Valve Regulated Lead Acid Option

### Figure 7

Table 4A

FIRM PRICE QUOTATION					
<u>QUOTE NO.:</u> 06202006-2215-MM		<u>QUOTE DATE:</u> June 20, 2006 <u>PREPARED BY:</u>			
<b>RFQ#</b>	(22) 500Amp -48VDC e/w (10)50A PCUs and 4 strings (4)12V-150AH VRLA				
<b>Quote To:</b>	<b>Ma and Pa Telecom Company</b> Pa Customer 1313 Mockingbird Lane Jamestown IN Ph 333-444-5555 Cell 444-999-2222 pa.customer@telecom-company.com				
	<b>Project Site:</b>	<b>Ma and Pa Telecom Company</b> Ma Customer 1314 Mockingbird Lane Jamestown IN Ph 444-555-2222 Cell 444-999-2222 ma.customer@telecom-company.com			
<u>TERMS:</u> 30 Days Net					
<u>PRICES VALID FOR:</u> 30 Days					
<u>PO REQUIRED:</u> To Proceed					

Item	Qty	Est.	P/N	Description			Unit Cost	Amount
<b>I</b>	1	Est.	C-F	<b>Customer Supplied - Furnishment of Materials (C-MA)</b> EF&I Vendor orders directly into Customer's Procurement System				
				<b>Breakout Pricing</b>	Power Room	Secondary Space		
				Add Material	\$ 377,811	\$ 111,225		
				Maintenance Material	\$ -	\$ -		
				Removal/Salvage Material	\$ -	\$ -		
<b>II</b>	1	Est.	C-LS	<b>Customer Supplied - Logistic Services (C-LS) to End-User's Logistic Center</b> EF&I Vendor will order materials to ship to end-user's Logistic Center				
				Start: 12-Sep-06				
				Finish: 8-Nov-06	Transportation Charges	\$ 73,355		
<b>A.</b>	1	Est.	E	<b>Factory Direct Engineering Services (EN)</b> Invoiced upon written acceptance of engineering package				
				Start: 12-Sep-06	<b>Breakout Pricing</b>	Power Room		
				Finish: 08-Nov-06	Add Labor	\$ 24,063	\$ 1,766	
					Maintenance Labor	\$ -	\$ -	
<b>B.</b>	1	Est.	F	<b>Furnishment of Materials (MA)</b> Invoiced at project start				
				Start: -	<b>Breakout Pricing</b>	<b>Total Project</b>		
				Finish: 8-Nov-06	Materials	\$ -		
<b>C.</b>	1	Est.	LS	<b>Logistic Services (LS)</b> Invoiced upon materials receipt at project site. - Freight: Bestway				
				Start: 14-Sep-06	Warehousing Charges	\$ -		
				Finish: 11-Dec-06	Transportation Charges	\$ 39,123		
					Inside Delivery	\$ -		
<b>D.</b>	1	Est.	I	<b>Factory Direct Field Services (FS)</b> Invoiced upon written acceptance of job completion				
				Start: 11-Dec-06	<b>Breakout Pricing</b>	Power Room		
				Finish: 12-Mar-07	Add Labor	\$ 132,403	\$ 9,720	
					Maintenance Labor	\$ -	\$ -	
					Removal/Salvage Labor	\$ -	\$ -	
					Transitions/Moves Labor	\$ -	\$ -	
					Outsourced Services [Subs]	\$ -	\$ -	
<b>***Quoted Project Start Date (No Later Than):</b>				<b>September 12, 2006</b>			<b>SUB TOTAL:</b>	\$ 207,075
<b>***Quoted Project 100% Completion Date (Ready For Service):</b>				<b>March 12, 2007</b>			<b>* TAXES:</b>	See Notes
							<b>** QUOTE TOTAL:</b>	\$ 207,075

Table 4B

	G	H	I	J	K	L	M	N	O	P	Q
2	RQ Date:	June 20, 2006	Customer Ref#:	(22) 500Amp 48VDC/w (10)50A PCUs and	BMW V9.02	EF&V Vendor #/Date #:	06/20/2006-2225/MM	Vendor PROJECT #:	September 5, 2006	Quote Date:	June 20, 2006
3	PO Date:	September 5, 2006	Customer PO#:		93	Project Start:		Role	FS N	Size	1
4	Data Date:	Calculated FS Working Days:	66.00	Total FS Calended Days:	93	Ready for Service:	March 12, 2007		FS III		1
5	Quote By:	MM	Total FS Labor Hours:	1,917.14	EN? (N/A)	Change Order (CO) #:			FS II		2
6	Com Bi:	ES Crew Size/Birthday-5 days/wk!	3.63	Premium Location?	NO	Walk-In Estimation?	YES		FS I		1
7	Sales Rep:	ACTUAL CREW SIZE (FTE)	4	Quoteline/voice Type:	30 - EN, IS, FN, LS, OS	Input FS Working Days:	66.00	Team:	TOTAL FS TEAM:		5
8	Fee (\$):	Days for crew sizes:	59.91	FS Expedited Date:	NO	Chance of Award:	75		Future 5		
9	TEAM:	EN Finish Days Float:	20	FS? (Y/N):	Yes	OH Applied:	\$7.00		Future 10:		
10	Specs:	PR Finish Days Float:	20	MA (Y/N):							
11	<b>Quote To (from Expect Tab):</b>										
12	Customer Company Name:	Mr. and Pa Telecom Company	Project Site Company Name:	Mr. and Pa Telecom Company		Project Site Last Name/Customer:		First Name:	Ma		
13	Contacts Last Name:	Customer	Address 1:	1314 Mockingbird Lane		Address 1:	1314 Mockingbird Lane				
14	Address 1:	1314 Mockingbird Lane	Town:	Jamesstown		Town:	Jamesstown	State:	IN		
15	Town:	Jamesstown	Notes:			Zip Code:		Notes:			
16	Zip Code:		Phone Number:	444-565-2222		Phone Number:	444-565-2222		Fax:		
17	Phone Number:	333-444-5555	Page#:			Cell Number:	444-569-2222		Paper:		
18	Fax Number:		Web Page:			Contact Email Address:	ma.customer@telecom-company.com	Web Page:			
21	Budgeted Roles:	Budgeted Hours:	Description:	# of Units	Average Unit Cost:	Total Estimated Cost:	Quoted Gmt	Quoted Amount:	Comments		
22											
23											
438	<b>PROJECT'S GRAND TOTALS PART I of II</b>										
439	Prospecting (PP)		PP TOTALS:	15	\$ 19.50	\$ 160.00	\$ 14.30%	\$ 187	% of Total Quote:	PP % of Total Quote	PP
440	4	4.00									46.75
441	II: Estimation (ET)		ET TOTALS:	40	\$ 37.73	\$ 1,500.00	\$ 4.73%	\$ 1,504	ET % of Total Quote:	ET % of Total Quote	ET
442	1	15.00									10.50
443	III: Professional Services (PS)		PS TOTALS:	846	\$ 24.72	\$ 20,923.23	\$ 12.91%	\$ 24,025	PS % of Total Quote:	PS % of Total Quote	PS
444	12	411.70									58.36
445	VI: Materials (MA)		MA TOTALS:	0	\$ -	\$ -	\$ -	\$ -	MA % of Total Quote:	MA % of Total Quote	MA
446	0	0.00									n/a
447	VII: Logistic Services (LS)		LS TOTALS:	1	\$ 39,122.88	\$ 39,122.88	0.00%	\$ 39,123	LS % of Total Quote:	LS % of Total Quote	LS
448	3	0.00									n/a
449	VIII: Outsourced Services (OS)		OS TOTALS:	0	\$ -	\$ -	\$ -	\$ -	OS % of Total Quote:	OS % of Total Quote	OS
450	0	0.00									n/a
451	IX: Field Services (FS)										FS % of Total Quote
452	5	1998.00	FS TOTALS:	4393	\$ 24.49	\$ 107,587.66	\$ 24.30%	\$ 142,123	68.63%:	68.63%	71.10
453	X: Knock Out (KO)		KO TOTALS:	2	\$ 18.50	\$ 27.75	\$ 15.91%	\$ 33	KO % of Total Quote:	KO % of Total Quote	KO
454	3	0.75									44.00
455	BUDGET: GRAND TOTALS								Projects Net GM:	Projects Net GM:	Projects Rate
456	28	2430	BUDGET GRAND TOTALS	5296	\$ 3.97	\$ 169,330.52	\$ 18.23%	\$ 207,075	18.00%:	18.00%:	85.20

## WEIGHTS, FLOOR LOADING AND NUMBER OF ADDITIONAL EQUIPMENT RACKS FOR SOLUTIONS

Solution Type:	DISTRIBUTIVE						BULK					
	Valve Regulated Lead Acid (VRLA)			Lithium Metal Polymer (LMP)			Lithium Ion Option (LI)			Flooded/Lead Acid (Wet)		
Description	Unit Weight (LBS)	Total Units	Unit Weight (LBS)	Total Units	Unit Weight (LBS)	Total Units	Unit Weight (LBS)	Total Units	Unit Weight (LBS)	Total Units	Total	
AC												
11.2kVA Transformers K-Factor Type												
208V Wiring	980.00	8.00	7840.90	8.00	7840.90	8.00	7840.90	8.00	7840.90	8.00	0.00	
480V Wiring	2.30	333.00	7665.90	2.30	3335.00	7665.90	2.30	3335.00	7665.90	2.30	0.00	
Panels with 6) 50Amp 1pole	7.20	400.00	2880.00	7.20	400.00	2880.00	7.20	400.00	2880.00	7.20	4320.00	
Panels with 7) 75Amp	350.00	8.00	2800.00	350.00	8.00	2800.00	350.00	8.00	2800.00	350.00	3200.00	
480V Wiring to Rec-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5550.00	
<b>Total AC Weight</b>											<b>13070.00</b>	
Power Plant												
Main Cabinet	72.00	22.00	1584.00	72.00	22.00	1584.00	72.00	22.00	1584.00	72.00	436.00	
Rectifier Bay	100.00	22.00	2200.00	100.00	22.00	2200.00	100.00	22.00	2200.00	100.00	480.00	
Supplement Bays	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1640.00	
Rectifiers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4000.00	
BDFB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6876.00	
Primary Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12545.00	
Bus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	386.00	
Battery Bus	10.00	22.00	220.00	10.00	22.00	220.00	10.00	22.00	220.00	10.00	30.00	
Power Room Walls and door	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3600.00	
Equipment Rack	150.00	44.00	6600.00	150.00	44.00	6600.00	150.00	44.00	6600.00	150.00	1560.00	
<b>Total Power Plant Weight</b>											<b>47957.00</b>	
Battery												
Weight of Battery	131.00	352.00	46112.00	60.60	530.00	32118.00	67.00	792.00	50064.00	683.00	384.00	
Weight of Shelves	56.00	88.00	4920.00	56.00	265.00	14840.00	0.00	0.00	0.00	0.00	26612.00	
Weight of Stands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5248.00	
Cable Assemblies with disconnected if available	9.97	88.00	877.36	0.63	530.00	333.90	0.63	792.00	498.96	640.00	12450.00	
<b>Total Battery Weight</b>											<b>286730.00</b>	
Total System Weight												
<b>Total Power Plant and Battery Weight</b>											<b>346757.00</b>	
Total Contact Area of All Power Plants												
<b>Total Power Plant Contact Floor Loading (Lbs/Square Foot)</b>											<b>333687.00</b>	
Total Weight Per Power Plant												
Total Contact Area of each Power Plant (Square Feet)												
<b>Total Power Plant Contact Floor Loading (Lbs/Square Foot)</b>											<b>333687.00</b>	
Total Area of all Transformer (Square Feet)												
Transformer Contact Floor Loading (Lbs/Square Foot)												
<b>Total Area of all Transformer (Square Feet)</b>											<b>333687.00</b>	
Transformer Contact Floor Loading (Lbs/Square Foot)												
<b>Total Area of all Transformer (Square Feet)</b>											<b>333687.00</b>	
Area for Solution IPower Plant and 208V												
Area difference compared to Bulk with Transformers												
Area Difference Compared to Bulk without Transformer. Assumes: SE = 208V												
Total Additional Revenue Producing Equipment Racks (2x2 each) - Not Including Aisle Spacing - Assumes SE = 208V												
Total Additional Revenue Producing Equipment Racks (2x2 each) - Not Including Aisle Spacing - Assumes SE = 208V												
<b>Total Additional Revenue Producing Equipment Racks (2x2 each) - Not Including Aisle Spacing - Assumes SE = 208V</b>											<b>679.00</b>	

TABLE 5