**Cost Analysis Between Conventional Power Whip and Overhead Starline Busway**

**Industry:** Enterprise Data Center, Raised Floor Application

**Floor Design:**

- 2 PDU units located north end of data center room.
- 4 Rows of rack.
- 6 Racks per row. Rows are centered in the room.
- 3 CRAC units on east wall of room.
- Please see DWG-01 for concept plan.

**Description of Analysis:** To compare contractor-installed power whips to each rack and breakers into the PDU when compared to Starline overhead busway product, including electrical contractor-installed pipe and wire from PDU to end feed connection box and installation of overhead busway. There are 2 PDU's, A and B; 2 whips for each rack, each whip with a separate 30A breaker in each PDU. Starline bus includes 4 feeder breakers in each PDU; 8 breakers total; and 2 over head bus runs for each row of racks. Each A and B bus run will be a homerun back to a breaker in each PDU.

**Scenario A:** The electrical contractor installs a 30A breaker into each PDU unit and installs the whip from the breaker under the raised floor with an L6-30 connection to the rack. Each rack requires (2) L6-30 whips. 48) 30A breakers are installed in the PDU; 24 for each PDU. 48 whips are installed; 2 per rack; 1 each from PDU A and PDU B for redundancy.

**Scenario B:** The customer purchases Starline overhead busway. The contractor installs pipe and wire from PDU main subfeed breakers to the end feed connection box. Each row of racks has an A and a B busway for redundancy. There are a total of 8 runs of busway. The contractor hangs the overhead busway using all-thread and busway hangers. Each rack requires 2 Starline bus plug boxes with an L6-30 receptacle and 30A breaker in the plug box. 1 plug box is installed in both the A and B busways for each rack for redundancy. There are a total of 48 boxes that the customer installs as needed. Due to the DWG-01 rack loads, 100A T3 and 225A T3 busway was used for this analysis. Plug boxes are interchangeable between both types of busway in the T3 Starline series.

**Findings for Each Scenario:**

**Scenario A:** See Table A-1 on the following page. Cost per rack is determined by including 2 whips per rack, (1) 30A breaker for each whip, labor to install breakers and whips, and all materials including the L6-30 receptacle. Total pricing includes 2 electricians for 4 days to install the base project of (48) whips and breakers. Pricing does not include PDU units, panelboards in the PDU's, or any materials to replace square tiles on the raised floor. If at any time, a new whip needs to be installed, per NFPA 70E, the PDU panel must be de-energized. This will require coordination of the loads and possible down time. There would be a minimum charge by the contractor of $500.00 plus an estimated charge of $850.00 per new whip.

**Scenario B:** See Table B-1 on the following page. Cost per rack is determined by including all Starline busway components including (2) L6-30 bus plug boxes per rack. The customer (end-user, owner) would install the bus plugs into the overhead busway. Cost per bus run (8 total runs) includes the contractor to install pipe and wire from the PDU breaker to each end feed box, making the connection to the PDU breaker and end feed, and hang the overhead busway using the Starline hangers and all-thread. Pricing does not include the PDU units or PDU breakers. Total pricing includes 2 electricians for 3 days to install the overhead busway and to make connections at the PDU breakers and end feed boxes. If at any time, a new bus plug receptacle box is needed, the estimated cost per box is $350.00. The end-user/owner can easily install additional boxes into the busway as needed. The installation can be completed without a shutdown. There is no need to de-energize the busway or disrupt the current loads. There is no need to de-energize the PDU. The bus plug receptacle box will have its own breaker for the receptacle.

**(Tables continued on next page.)**

| Table A-1 | | |
|---|---|---|
| | L6-30 Receptacle | |
| | 2 whips per rack | |
| | Breaker in each PDU | |
| Rack# | Cost/Rack | |
| 1 | $ | 480.70 |
| 2 | $ | 531.30 |
| 3 | $ | 609.60 |
| 4 | $ | 660.00 |
| 5 | $ | 712.80 |
| 6 | $ | 765.60 |
| 7 | $ | 660.00 |
| 8 | $ | 712.80 |
| 9 | $ | 765.60 |
| 10 | $ | 818.40 |
| 11 | $ | 871.20 |
| 12 | $ | 922.80 |
| 13 | $ | 818.40 |
| 14 | $ | 871.20 |
| 15 | $ | 924.00 |
| 16 | $ | 976.80 |
| 17 | $ | 1,029.60 |
| 18 | $ | 976.80 |
| 19 | $ | 1,029.60 |
| 20 | $ | 1,082.40 |
| 21 | $ | 1,135.20 |
| 22 | $ | 1,188.00 |
| 23 | $ | 1,240.80 |
| 24 | $ | 1,293.60 |
| **Total** | **$** | **21,077.20** |

(2) tradesmen for (4) days for base install
Per code, shutdown PDU to install new whip
New whip = $500 min., $850/whip

| Table B-1 | |
|---|---|
| A&B Starline Busway | |
| A&B bus plug per rack | |
| System Hardware & Equipment | |
| End feeds | $ 2,868.00 |
| Straight bus | $ 1,704.00 |
| Straight bus | $ 3,039.00 |
| Hangers | $ 207.00 |
| Joint kits | $ 330.00 |
| End caps | $ 69.60 |
| Install tool | $ 108.00 |
| Bus plugs 2 rec/rack | $ 10,848.60 |
| | |
| Total Hardware | $ 19,174.20 |
| **Cost/Rack (24 racks w/ 2rec. Each)** | **$ 798.93** |
| Contractor Run Pipe & Wire from PDU Breaker to each end feed box, Hang Busway | $ 6,600.00 |
| **Labor cost to install/bus run (8 runs)** | **$ 825.00** |

(2) tradesmen for (3) days for base install
No shutdown of PDU and no de-energizing of busway for new plug box install
New bus plug = est. $350.00 No labor needed.

**Total Cost for Each Scenario:**

| Total Cost for Base Installation of Both Scenarios | | |
|---|---|---|
| Whip Installation | | Starline Installation |
| $ 21,077.20 | | $ 25,774.20 |

Table B-2 shows a breakdown of budget per 1 foot of 250A Starline busway. Quantities and busway are determined per job. This example for the Starline 250A overhead busway includes (1) end feed box, (1) 10' section of busway, (2) hangers, (1) joint kit, (1) end cap, and (1) installation tool. Contractor labor to make connections and to hang the busway is not included. This is a budget price for reference. Bus plug receptacle boxes are not included.

| Table B-2 | |
|---|---|
| Cost/10' section **250A** bus | |
| End feed | $ 634.80 |
| 10' section bus | $ 1,003.95 |
| Hangers | $ 18.17 |
| Joint kit | $ 100.05 |
| End cap | $ 14.49 |
| Install tool | $ 190.90 |
| **1' section of bus** | **$ 196.24** |

The average per bus plug box price for the higher 250A T5 Starline series is $450.00 per plug. Every project bus plug is custom. The plug may need multiple receptacles, drop cord units, metering, etc. which will increase the pricing of the unit.

Table S-1 Is a explanation of additional power distribution needs for Scenarios A and B described above. The cost of ownership is provided in the breakdown below. After the base installation project of distribution power to the racks, there will be a need for additional receptacles. Table S-1 includes the cost per whip (new breaker in PDU, labor, cable, receptacle end, other small materials required for the whip) for installation, daily minimum charge, and cost per Starline bus plug receptacle box. The Starline plug cost does not include installation labor since the owner can install the unit into the busway.

| Table S-1 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Installation for additional whip per daily charge | $500.00 | | | | | | |
| Per whip charge | $850.00 | | | | | | |
| Starline Plug Box (no labor needed) | $350.00 | | | | | | |
| Comparison after Base Project Installation | | | | | | | |
| | | | | | | | |
| After Day One | | | | | | | |
| Customer needs (2) more receptacles | | | | | | | |
| | # of Days | Labor Daily Charge | Per Whip | # of Whips | # of Starline Plugs | Per Starline Plug Box | Total |
| Whip Scenario | 1 | $ 500.00 | $ 850.00 | 2 | | | $ 2,200.00 |
| Starline Plug | | | | | 2 | $ 350.00 | $ 700.00 |
| | | | | | | | |
| Customer needs (18) more receptacles | | | | | | | |
| Whip Scenario | 2 | $ 500.00 | $ 850.00 | 18 | | | $ 16,300.00 |
| Starline Plug | | | | | 18 | $ 350.00 | $ 6,300.00 |
| | | | | | | | |
| Customer needs (5) more receptacles | | | | | | | |
| Whip Scenario | 1 | $ 500.00 | $ 850.00 | 5 | | | $ 4,750.00 |
| Starline Plug | | | | | 5 | $ 350.00 | $ 1,750.00 |
| | | | | | | | |
| | | | | | **Total After Day 1 Costs** | **Whips** | **$23,250.00** |
| | | | | | | **Starline** | **$ 8,750.00** |

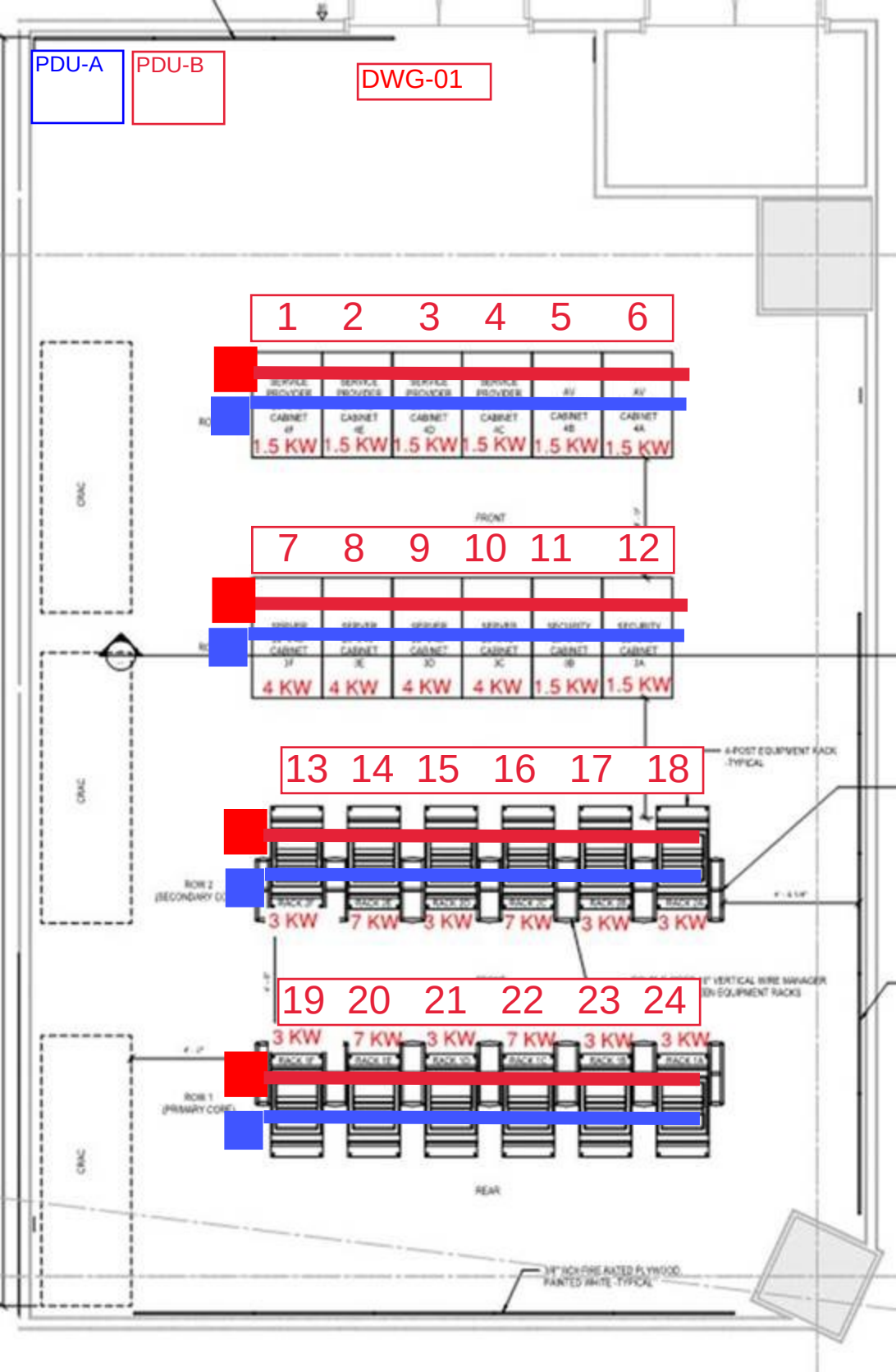
Comparison reveals that the conventional whips installed by the electrical contractor are slightly less expensive during the initial project installation. Starline equipment could be considered an asset of the company and can be recorded as such on the company's financial statements (this is dependent on how the owner of the Starline system classifies their assets). Also, if the owner moves to a different location or redesigns the area, the Starline equipment can be relocated. Per NFPA 70E and various OSHA codes,

the PDU must be de-energized for the installation of additional breakers and whips in the PDU. The owner assumes responsibility if breakers are installed in live panelboards. The owner has increased risk of injury and downtime with installation of breakers and whips in a conventional PDU panelboard. Starline busway does not need to be de-energized to install a new plug box. Starline manufacturers a solution that is considered finger-safe and the plug boxes are grounded when inserting and locking into place when uninstalling. The plug boxes have a grounded connection design that is first-make, last-break when installing and removing the box from the busway. Starline recommends following proper local safety code and to wear appropriate PPE based on site arc flash study.

Table S-1 shows the cost of ownership after the base project is installed. The Starline equipment cost is less than half that of the whip installation. There is no labor cost for Starline addition when additional receptacles are needed. The average plug box is less expensive than one additional whip installation. An added benefit of the Starline product to the owner is increased security of the data center. Third party access is not required to make changes or additions to the system. Third party access typically requires safety training, customer escort and customer supervision.

Overhead bus also improves the efficiency of raised floor air distribution systems. Underfloor whips constrict air movement which increases energy usage from the CRAC units. Overhead busway eliminates air restriction issues.

**Conclusion of Analysis:** The purpose of the analysis was to provide a comparison between data center power distribution solutions. Conventional power whips have a first cost advantage over the Starline solution. But, the first cost savings is eliminated after qty 7 additional whip installations. Beyond the cost analysis, the Starline solution has many notable advantages over the conventional whip installation. Starline busway increases speed to implementation of new equipment with enhanced flexibility and self-controlled installation. The Starline solution reduces owner risk, downtime and costs after the systems are online. This analysis focused on a data center space with raised floor. However, the advantages above can also be realized in a manufacturing setting as well. Manufacturing and industrial spaces benefit from minimized down-time and availability of flexible distribution power.


PDU-A
PDU-B
DWG-01
1 2 3 4 5 6
1.5 KW 1.5 KW 1.5 KW 1.5 KW 1.5 KW 1.5 KW
FRONT
7 8 9 10 11 12
4 KW 4 KW 4 KW 4 KW 1.5 KW 1.5 KW
13 14 15 16 17 18
3 KW 7 KW 3 KW 7 KW 3 KW 3 KW
19 20 21 22 23 24
3 KW 7 KW 3 KW 7 KW 3 KW 3 KW
REAR
CRAC
CRAC
CRAC