Effects of Battery Technology on 48V DC Power System Layout for Telecom and Data Buildings

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Abstract

Different battery technologies (Flooded cells, Sealed Lead Acid, Sodium, Lithium, etc.) have had and continue to have a significant impact on the layout of a building's 48V DC power infrastructure. Size, weight, safety concerns and capacity of the battery technology all play a role in the physical placement of the energy reserve within a building. The effects of the location within the building can have significant implications on initial cost, operating cost, installation time and building structural requirements.

Continued increase in the demand for Telecom and Data services place a continued increase in the demand for more energy. In the past, energy demands from network elements had a slow linear growth year over year, whereas today's growth is more exponential. The ability to have a building's energy delivery infrastructure adapt to the significant energy demand increase year over year without a removal and rebuild is key to rapid deployment of new services as well as cost competiveness. Battery technology is a key element in defining a building's layout of the energy infrastructure and therefore, is a key element in the ability to adapt to the increasing demand for Telecom and Data services.

A review of the different building energy infrastructures used in the past, current layouts, and possible future layouts are examined side by side. Everything from cost of copper, installation time, operating costs and structural impacts are explored.

48VDC System Architectures

48VDC systems can be deployed within a building in basically three different types of architectures: Centralized, Distributed or Integrated.

Centralized Architecture

Centralized architectures consolidate the entire building's DC power needs into one location within the building, with feeder cables running to the locations where the power is needed. Localized DC sub distribution panels/cabinets are typically placed nearer to the DC powered equipment such that fewer larger cables are run throughout the building. While not limited to flooded battery technology, it is typically the battery of choice for this type of architecture.

Distributed Architecture

Distributed architectures deploy multiple "pods" of smaller DC power systems throughout the building, nearer to the locations where the power is needed. The DC power systems are typically cabled directly to the DC powered equipment and DC sub distribution panels/cabinets are not used. Again while not limited to sealed lead acid batteries, they are typically used in this type of architecture due to their smaller foot print and closer proximity to the DC powered equipment.

Integrated Architecture

Integrated architectures deploy the DC power system directly into the DC powered equipment line up or cabinets. At this level, many more but smaller ampacity systems are deployed. Again while not limited to alternative technology batteries (Lithium Ion, sodium, etc.) they are typically used in this type of architecture due to their smaller foot print and their close proximity to the DC powered equipment.

Throughout the three different architectures (Centralized, Distributed, Integrated) many of the system elements remain consistent: Power conversion from AC to DC is typically done using high frequency switching power supplies, DC protection devices are magnetic circuit breakers or thermal fuses, overhead open cable racks are used to support the cabling and copper wire cable pairs are used to distribute the DC power. What does commonly vary from architecture to architecture and typically defines the type of architecture deployed is the choice of battery; Flooded Lead Acid batteries in the Centralized Architecture, Sealed Lead Acid batteries in the Distributed Architecture and Alternative Energy batteries in the Integrated Architecture

Architecture Comparisons

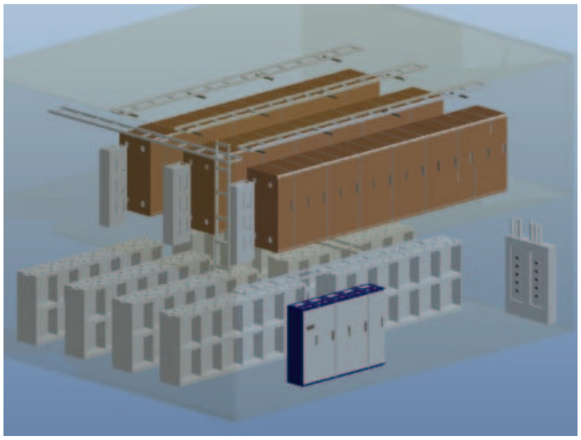
The three architectures can be compared and contrasted on a variety of quantitative and subjective attributes. In this paper we will limit the comparison to the quantitative attributes of cable cost, installation time, floor space and overall system efficiency. While subjective attributes (familiarity with a technology, division of organizational territories within the building, safety, reliability/availability etc.) can be extremely important factors in the decision of which type of architecture to deploy within a building, they will not be discussed here.

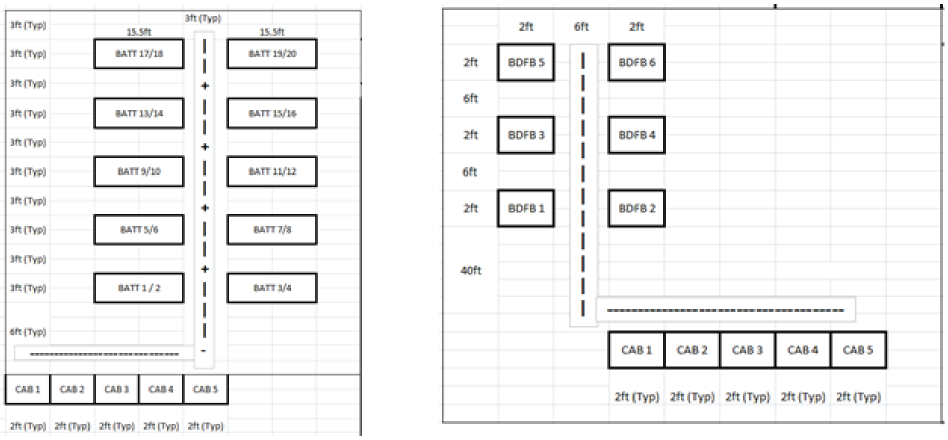
For our comparison, we will study a building with a 6000Amp, 48Vdc (300KW) DC demand deployed to (150) 40amp DC circuits.

Centralized Architecture

Centralized Architecture consolidates the entire building's DC power needs into one location within the building, in this case in the basement or ground floor, with feeder cables running to the locations where the power is needed. Localized DC distribution panels/cabinets (BDFBs, BDCBBs) are placed nearer to the DC powered equipment to sub breaker/fuse protect the DC power.

Centralized Floor Plan





Battery to Power System

Power System to DC Distribution

DC Distribution to NE

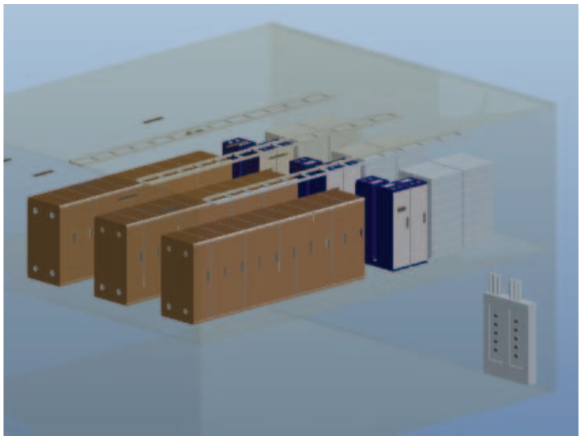
2ft	2ft	2ft	3ft		2ft	6ft	3ft	2ft	2ft	2ft	2ft
NE LOAD 5/3	NE LOAD 5/2	NE LOAD 5/1	ROW 5	2ft	BDFB 5/A BDFB 5/B		BDFB 6/A BDFB 6/B	ROW 6	NE LOAD 6/1	NE LOAD 6/2	NE LOAD 6/3
				6ft							
NE LOAD 3/3	NE LOAD 3/2	NE LOAD 3/1	ROW 3	2ft	BDFB 3/A BDFB 3/B		BDFB 4/A BDFB 4/B	ROW 4	NE LOAD 4/1	NE LOAD 4/2	NE LOAD 4/3
				6ft							
NE LOAD 1/3	NE LOAD 1/2	NE LOAD 1/1	ROW 1	2ft	BDFB 1/A BDFB 1/B		BDFB 2/A BDFB 2/B	ROW 2	NE LOAD 2/1	NE LOAD 2/2	NE LOAD 2/3

Figure 1 - Centralized Battery – Power System Floor Plan

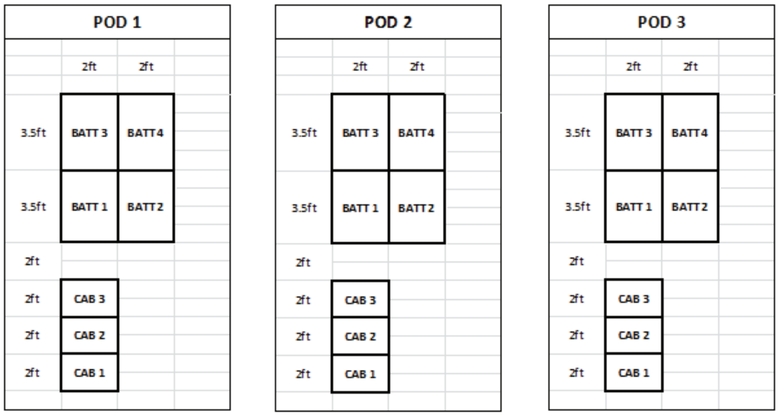
Distributed Architecture

Distributed Architecture deploys multiple “pods” of smaller DC power systems throughout the building. They are deployed nearer to the locations where the power is needed. The DC power systems are cabled directly to the DC powered equipment and DC sub distribution panels/cabinets are not used.

Distributed Floor Plan



Battery to Power System and DC Distribution

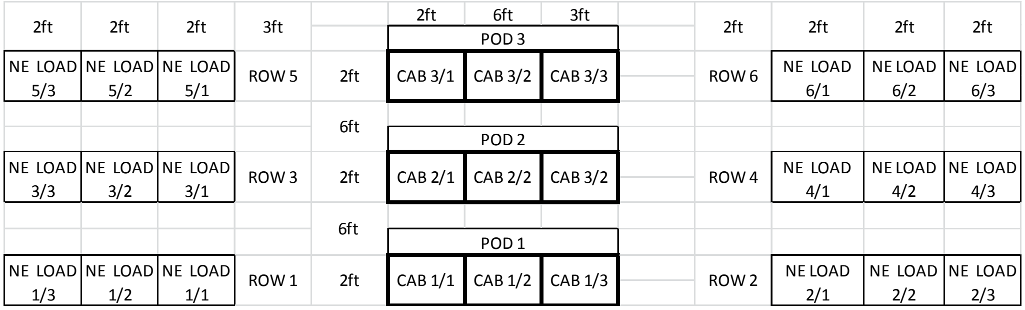


POD 1		
	2ft	2ft
3.5ft	BATT 3	BATT 4
3.5ft	BATT 1	BATT 2
2ft		
2ft	CAB 3	
2ft	CAB 2	
2ft	CAB 1	

POD 2		
	2ft	2ft
3.5ft	BATT 3	BATT 4
3.5ft	BATT 1	BATT 2
2ft		
2ft	CAB 3	
2ft	CAB 2	
2ft	CAB 1	

POD 3		
	2ft	2ft
3.5ft	BATT 3	BATT 4
3.5ft	BATT 1	BATT 2
2ft		
2ft	CAB 3	
2ft	CAB 2	
2ft	CAB 1	

DC Distribution to Network Loads



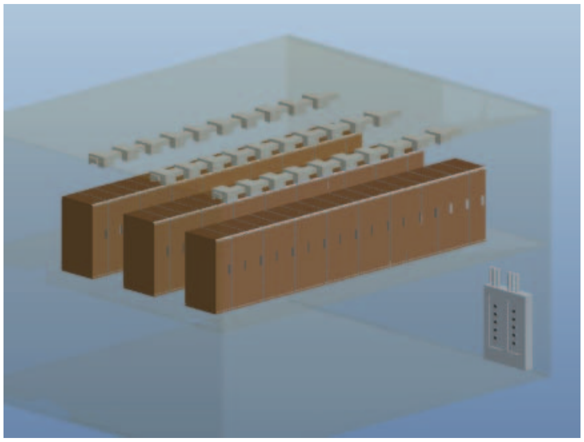
2ft	2ft	2ft	3ft		2ft	6ft	3ft		2ft	2ft	2ft	2ft
						POD 3						
NE LOAD 5/3	NE LOAD 5/2	NE LOAD 5/1	ROW 5	2ft	CAB 3/1	CAB 3/2	CAB 3/3		ROW 6	NE LOAD 6/1	NE LOAD 6/2	NE LOAD 6/3
				6ft		POD 2						
NE LOAD 3/3	NE LOAD 3/2	NE LOAD 3/1	ROW 3	2ft	CAB 2/1	CAB 2/2	CAB 3/2		ROW 4	NE LOAD 4/1	NE LOAD 4/2	NE LOAD 4/3
				6ft		POD 1						
NE LOAD 1/3	NE LOAD 1/2	NE LOAD 1/1	ROW 1	2ft	CAB 1/1	CAB 1/2	CAB 1/3		ROW 2	NE LOAD 2/1	NE LOAD 2/2	NE LOAD 2/3

Figure 2 - Distributed Power System Floor Plan

Integrated Architecture

Integrated Architectures deploys the entire DC power system (Batteries, Power conversion and DC Distribution) directly into the NE element equipment line up or cabinets. At this level, many more but smaller ampacity systems are deployed.

Integrated Floor Plan



Battery to Power System to DC Distribution

INTEGRATED SYSTEM								
ROW 1 , IS 1								
	2ft		**2ft**		**2ft**			
NE LOAD	CAB 1	NE LOAD	**CAB 2**	NE LOAD	**CAB 3**	NE LOAD	**CAB 4**	NE LOAD
ROW 2 , IS 2								
NE LOAD	CAB 1	NE LOAD	**CAB 2**	NE LOAD	**CAB 3**	NE LOAD	**CAB 4**	NE LOAD
ROW 3, IS 3								
NE LOAD	CAB 1	NE LOAD	**CAB 2**	NE LOAD	**CAB 3**	NE LOAD	**CAB 4**	NE LOAD

Figure 3 - Integrated Power System Floor Plan

Spatial Comparison

While spatial values can vary greatly from one battery technology to another for a given energy storage capacity, the power conversion and DC distribution densities have much smaller variations in current technologies.

Comparing products and technologies of actual equipment floor space is important but also total floor space which includes aisle walkways and maintenance space is equally important.

Significant spatial gains can be achieved when moving from flooded batteries in the centralized architecture to sealed lead acid or alternative technologies batteries in the other technologies. When the size of the battery dominated the percentage of the total spatial requirement, as in the case of flooded batteries, any change in battery size manifested itself in a significant total spatial impact. As the battery sizes as a percentage of the total spatial requirement comes down, changes in battery size have a smaller impact on the total spatial needs.

Table 1 - Spatial Summary

Spatial Summary

Attribute	Centralized	Distributed	Integrated	Notes
	Battery			
Space actual equipment (Sq ft)	435	28	0	
Space total floor space (Sq ft)	1476	130	0	
Number of elements/cabinets	20	12	0	
Estimated installation time	200	120	0	
	Power System			
Space actual equipment (Sq ft)	20	36	80	
Space total floor space (Sq ft)	50	54	200	
Number of elements/cabinets	5	9	12	1
Estimated installation time	50	90	120	
	DC Distribution			
Space actual equipment (Sq ft)	18	0	0	
Space total floor space (Sq ft)	96	0	0	
Number of elements/cabinets	6	0	0	
Estimated installation time	60	0	0	
	Totals			
Space actual equipment (Sq ft)	473	64	80	
Space total floor space (Sq ft)	1622	184	200	2
Number of elements/cabinets	31	21	12	
Estimated installation time	310	210	120	

1) Integrated cabinets double deep
2) Battery technology choice can significantly affect the spatial requirement

Cable Comparison

Minimizing DC voltage drops from the battery to the NE equipment loads is the dominant factor in cable size requirements of the different architectures. This is of course greatly influenced by the physical distance between the elements.

Power loss in the cabling from the power system to the Network Equipment loads under the different architecture styles should also be considered.

Table 2 - Cable Summary

Cable Summary

Attribute	Centralized	Distributed	Integrated	Notes
	Battery to Power System			
Cable Length (ft)	2112	240	0	
Cable Weight (lbs)	5702	648	0	
Cable Install time (hrs)	264	30	0	1
Cable rack length (ft)	46	45	0	
Cable rack install time (hrs)	5	5	0	2
	Power System to DC Distribution			
Cable Length (ft)	2472	0	0	
Cable Weight (lbs)	6674	0	0	
Cable Install time (hrs)	309	0	0	1
Cable rack length (ft)	68	0	0	
Cable rack install time (hrs)	7	0	0	2
Power loss in cable (W)	1166	0	0	
	DC Distribution to NE Load			
Cable Length (ft)	9000	9400	3408	
Cable Weight (lbs)	4230	4418	1602	
Cable Install time (hrs)	180	188	68	1
Cable rack length (ft)	324	330	350	
Cable rack install time (hrs)	32	33	35	2
Power loss in cable (W)	2478	3860	937	
	Totals			
Cable length (ft)	13584	9640	3408	
Cable weight (lbs)	16607	5066	1602	
Cable Install time (hrs)	753	218	68	1
Cable rack length (ft)	438	375	350	
Cable rack install time (hrs)	44	38	35	2
Power loss in cable (W)	3644	3860	937	
Power loss % of total power	1.21%	1.29%	0.31%	

1) Cable 750MCM, 8ft/hr. 2g, 50ft/hr
2) Cable rack 10ft/hr

Discussion

While the different architectures are not exclusively tied to a specific battery technology they are heavily influenced by it. When examining a change to any one specific equipment element in a system, it seems prudent to study the impact of the given element's change on the total system.

Integrated architectures seem to offer significant advantages over both Centralized and Distributed architectures in terms of cable cost, installation time, floor space and total systems efficiency. However other factors such as familiarity with a technology, division of organizational territories within the building, safety, and reliability/availability cannot be ignored.

Table 3 - Summary

Summary

Attribute	Centralized	Distributed	Integrated	Reduction	Reduction %
	Battery to Power System				
Cable Length (ft)	2112	240	0	2112	**100%**
Cable Weight (lbs)	5702	648	0	5702	**100%**
Cable Install time	264	30	0	264	**100%**
Space actual equipment (Sq ft)	435	28	0	435	**100%**
Space total floor space (Sq ft)	1476	130	0	1476	**100%**
	Power System to DC Distribution				
Cable Length (ft)	2472	0	0	2472	**100%**
Cable Weight (lbs)	6674	0	0	6674	**100%**
Cable Install time	309	0	0	309	**100%**
Space actual equipment (Sq ft)	20	36	80	-60	**-300%**
Space total floor space (Sq ft)	50	54	200	-150	**-300%**
Power loss in cable (W)	1166	0	0	1166	**-**
	DC Distribution to NE Load				
Cable Length (ft)	9000	9400	3408	5592	**62%**
Cable Weight (lbs)	4230	4418	1602	2628	**62%**
Cable Install time	180	188	68	112	**62%**
Space actual equipment (Sq ft)	18	0	0	18	**100%**
Space total floor space (Sq ft)	96	0	0	96	**100%**
Power loss in cable (W)	2478	3860	937	1541	**62%**
	Totals				
Cable length (ft)	13584	9640	3408	10176	**75%**
Cable weight (lbs)	16607	5066	1602	15005	**90%**
Cable Install time	753	218	68	685	**91%**
Space actual equipment (Sq ft)	473	64	80	393	**83%**
Space total floor space (Sq ft)	1622	184	200	1422	**88%**
Power loss in cable (W)	3644	3860	937	2707	**74%**
Power loss % of total power	1.21%	1.29%	0.31%	0.90%	**74%**

With copper spot prices running close to $4/lb. the copper reduction by 15,000 pounds translates to real savings of $60,000, with a reduction in installation cost of an additional $51,400 (685 hours @ $50/hr.)

DC Electrical Loss savings are in the order of $2,400 per year at $0.10/KWhr.

DC Electrical Losses may be partially offset by the need to run AC Power to several locations within the Network Equipment Area, but use of 480V 3-phase AC input Rectifiers minimizes this effect. This is also highly dependent on building AC infrastructure layout and whether you are replacing an existing system or installing new.

References

1. Cable Ampacity ratings per NEC TABLE 310.15(B)(16)